

Regression Analysis on Spotify Song Attributes - MATH564

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Introduction

Problem Statement: This analysis aims to understand the relationship between various song attributes and their total playback time (`msPlayed`) on Spotify. The objective is to identify which factors significantly influence playback duration and uncover patterns or trends in user engagement.

Project Goal: To develop a regression model that predicts song playback time (`msPlayed`) based on:

- **Continuous attributes** such as `danceability`, `energy`, and `tempo`.
- **Categorical attributes** such as `genre` and `artistName`.

Expected Results/Outcomes:

- A regression model explaining significant variations in playback time.
- Insights into how song attributes influence user engagement.
- Identification and remediation of model issues to improve accuracy and reliability.

Dataset Overview: The Spotify Song Attributes dataset includes 10,080 records with 22 variables describing various song features. Key attributes include:

- **Response Variable:** `msPlayed` (total playback duration in milliseconds).
- **Continuous Variables:** `danceability`, `energy`, `tempo`, `loudness`.
- **Categorical Variables:** `genre`, `artistName`.

Preprocessing and cleaning were required to handle missing values, inconsistencies, and outliers to ensure the quality of the insights and predictions.

Project Workflow

Part 1: Initial Analysis

This phase established the groundwork for model development, including data preparation, feature selection, model specification, and statistical analysis.

Dataset Selection and Exploration

1. The Spotify dataset was chosen for its real-world relevance and inclusion of both continuous and categorical variables.
2. **Response Variable:** `msPlayed`.
3. **Predictors:**
 - Continuous: `danceability`, `energy`, `tempo`.
 - Categorical: `genre`, `artistName`.

Data Cleaning

1. **Handling missing values:**
 - Missing values in `danceability`, `energy`, and `tempo` were imputed using KNN imputation to maintain data integrity.
2. **Cleaning categorical variables:**
 - `genre` and `artistName` were standardized (e.g., lowercase conversion, grouping rare categories as “Other”).
3. **Outlier handling:**
 - Extreme values in continuous variables (`danceability`, `energy`, and `tempo`) were capped using the IQR method.
4. **Normalization:**
 - Continuous variables were scaled to a 0-1 range for comparability.

Model Specification

1. A multiple linear regression model was defined:
 - **Response Variable:** `msPlayed`.
 - **Predictors:** `danceability`, `energy`, `tempo`, `genre`, and `artistName`.
2. The model was fitted, and overall significance was evaluated using F -statistics.

Statistical Significance and Interpretation

1. **Regression Coefficients:** Interpretation of predictors (significant and non-significant) was completed.
 2. **Goodness-of-Fit Metrics:** Model $R^2 = 0.0841$ and Adjusted $R^2 = 0.04247$ indicated room for improvement, highlighting the need for diagnostics and refinement.
-

Part 2: Regression Diagnostics

This phase investigates model assumptions and identifies potential issues to address for improved reliability.

Assumptions and Potential Issues

1. **Heteroscedasticity:** Diagnostic plots are being generated and analyzed.
2. **Multicollinearity:** Variance Inflation Factor (VIF) is being assessed.
3. **Influential Points:** Cook's Distance and leverage values are being calculated.

Status: Diagnostics are partially completed, with findings documented for heteroscedasticity and multicollinearity. Influential point analysis is in progress.

Part 3: Remediation and Refinement

This phase addresses issues identified in the diagnostic phase.

Remediation

1. Proposed Remediation Techniques:

- Logarithmic transformations for heteroscedasticity.
- Weighted Least Squares to address unequal variance.
- Polynomial or interaction terms for non-linear relationships.
- Adjusting for influential points based on diagnostics.

2. Re-fitting and Comparison:

- The model will be refitted after applying remediation techniques, with improvements and limitations documented.
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Summary and Findings

This final phase summarizes the analysis, discussing key findings, diagnostic issues, and the effectiveness of remediation techniques.

Let's Dive into the Implementation part now - # **Part 1: Initial Analysis** ## 1. Data Selection and Exploration - We chose a realworld dataset containing both continuous and Categorical Variables. Now let's focus on Exploration for which we will first have to-

1.1 Load the necessary libraries and dataset:

```
# Load necessary libraries
library(dplyr) # For data manipulation
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##   filter, lag

## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union

library(ggplot2) # Optional, for visualization if needed
#install.packages("VIM") # KNN imputation
library(VIM)

## Warning: package 'VIM' was built under R version 4.4.2

## Loading required package: colorspace

## Loading required package: grid

## VIM is ready to use.

## Suggestions and bug-reports can be submitted at: https://github.com/statistikat/VIM/issues

##
## Attaching package: 'VIM'

## The following object is masked from 'package:datasets':
##
##   sleep

library(corrplot)

## corrplot 0.94 loaded

# Load necessary library for diagnostic tests
library(lmtest)

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##   as.Date, as.Date.numeric
```

```
# Multicollinearity
library(car)
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
## recode
```

```
# Load the Spotify attribute dataset
data <- read.csv("./data/Spotify_Song_Attributes.csv")
# Create a copy of the spotify attribute dataset
spotify_data <- data
# View the first few rows to understand the structure
head(spotify_data)
```

```
##                                     trackName
## 1                                     "Honest"
## 2 "In The Hall Of The Mountain King" from Peer Gynt Suite N°1, Op. 46
## 3                                     #BrooklynBloodPop!
## 4                                     $10
## 5                                     (I Just) Died In Your Arms
## 6                                     (L)only Child
##           artistName msPlayed           genre danceability energy key
## 1           Nico Collins   191772           0.476 0.799 4
## 2 London Symphony Orchestra 1806234 british orchestra 0.475 0.130 7
## 3                SyKo    145610           glitchcore 0.691 0.814 1
## 4           Good Morning   25058 experimental pop 0.624 0.596 4
## 5           Cutting Crew  5504949           album rock 0.625 0.726 11
## 6           salem ilese  2237969           alt z      0.645 0.611 8
## loudness mode speechiness acousticness instrumentalness liveness valence
## 1  -4.939  0      0.2120      0.0162      0.00e+00 0.2570 0.577
## 2 -17.719  1      0.0510      0.9160      9.56e-01 0.1010 0.122
## 3  -3.788  0      0.1170      0.0164      0.00e+00 0.3660 0.509
## 4  -9.804  1      0.0314      0.4750      2.03e-01 0.1190 0.896
## 5 -11.402  0      0.0444      0.0158      1.69e-04 0.0625 0.507
## 6  -5.925  0      0.1370      0.2900      2.05e-05 0.2370 0.645
##      tempo           type           id
## 1 162.139 audio_features 7dTxqsaFGHOXwtzHINjfHv
## 2 112.241 audio_features 14Qcrx6Dfjvcj0H8oV8oUW
## 3 132.012 audio_features 7K9Z3yFNNLv5kwTjQYGjnu
## 4 120.969 audio_features 3koAwrm1R00TGMeQJ3qt9J
## 5 124.945 audio_features 4ByEF0BuLXpCqv01kw8Wdm
## 6 157.475 audio_features 22lJaG2yxlSjIwdUIddcFk
##                                     uri
## 1 spotify:track:7dTxqsaFGHOXwtzHINjfHv
## 2 spotify:track:14Qcrx6Dfjvcj0H8oV8oUW
## 3 spotify:track:7K9Z3yFNNLv5kwTjQYGjnu
## 4 spotify:track:3koAwrm1R00TGMeQJ3qt9J
```

```
## 5 spotify:track:4ByEF0BuLXpCqv01kw8Wdm
## 6 spotify:track:22lJaG2yxlSjIwdUIddcFk
##                                     track_href
## 1 https://api.spotify.com/v1/tracks/7dTxqsaFGHOXwtzHINjfHv
## 2 https://api.spotify.com/v1/tracks/14Qcrx6Dfjvcj0H8oV8oUW
## 3 https://api.spotify.com/v1/tracks/7K9Z3yFNNLv5kwTjQYGjnu
## 4 https://api.spotify.com/v1/tracks/3koAwrm1R00TGMeQJ3qt9J
## 5 https://api.spotify.com/v1/tracks/4ByEF0BuLXpCqv01kw8Wdm
## 6 https://api.spotify.com/v1/tracks/22lJaG2yxlSjIwdUIddcFk
##                                     analysis_url duration_ms
## 1 https://api.spotify.com/v1/audio-analysis/7dTxqsaFGHOXwtzHINjfHv      191948
## 2 https://api.spotify.com/v1/audio-analysis/14Qcrx6Dfjvcj0H8oV8oUW      150827
## 3 https://api.spotify.com/v1/audio-analysis/7K9Z3yFNNLv5kwTjQYGjnu      145611
## 4 https://api.spotify.com/v1/audio-analysis/3koAwrm1R00TGMeQJ3qt9J        89509
## 5 https://api.spotify.com/v1/audio-analysis/4ByEF0BuLXpCqv01kw8Wdm      280400
## 6 https://api.spotify.com/v1/audio-analysis/22lJaG2yxlSjIwdUIddcFk      144468
## time_signature
## 1                4
## 2                4
## 3                4
## 4                4
## 5                4
## 6                3
```

Inference: The dataset is successfully loaded into R, and a copy (`spotify_data`) is created to preserve the original data. We can now inspect the first few rows to understand its structure.

1.2 View Dataset Structure

```
# View the structure of the data
str(spotify_data)
```

```
## 'data.frame':    10080 obs. of  22 variables:
## $ trackName      : chr  "\"Honest\"" "\"In The Hall Of The Mountain King\"" from Peer Gynt Suite N°
## $ artistName     : chr  "Nico Collins" "London Symphony Orchestra" "SyKo" "Good Morning" ...
## $ msPlayed       : int  191772 1806234 145610 25058 5504949 2237969 441335 70589 120005 107407 ...
## $ genre          : chr  "" "british orchestra" "glitchcore" "experimental pop" ...
## $ danceability    : num  0.476 0.475 0.691 0.624 0.625 0.645 0.663 NA 0.792 0.759 ...
## $ energy          : num  0.799 0.13 0.814 0.596 0.726 0.611 0.904 NA 0.511 0.699 ...
## $ key             : num  4 7 1 4 11 8 7 NA 2 0 ...
## $ loudness        : num  -4.94 -17.72 -3.79 -9.8 -11.4 ...
## $ mode            : num  0 1 0 1 0 0 1 NA 1 0 ...
## $ speechiness     : num  0.212 0.051 0.117 0.0314 0.0444 0.137 0.0857 NA 0.0409 0.0307 ...
## $ acousticness    : num  0.0162 0.916 0.0164 0.475 0.0158 0.29 0.000708 NA 0.124 0.202 ...
## $ instrumentalness: num  0.00 9.56e-01 0.00 2.03e-01 1.69e-04 2.05e-05 2.89e-01 NA 9.04e-05 1.31e-0
## $ liveness        : num  0.257 0.101 0.366 0.119 0.0625 0.237 0.341 NA 0.14 0.443 ...
## $ valence         : num  0.577 0.122 0.509 0.896 0.507 0.645 0.675 NA 0.111 0.907 ...
## $ tempo           : num  162 112 132 121 125 ...
## $ type            : chr  "audio_features" "audio_features" "audio_features" "audio_features" ...
## $ id              : chr  "7dTxqsaFGHOXwtzHINjfHv" "14Qcrx6Dfjvcj0H8oV8oUW" "7K9Z3yFNNLv5kwTjQYGjnu"
## $ uri             : chr  "spotify:track:7dTxqsaFGHOXwtzHINjfHv" "spotify:track:14Qcrx6Dfjvcj0H8oV8oUW"
```

```
## $ track_href      : chr "https://api.spotify.com/v1/tracks/7dTxqsaFGH0XwtzHINjfHv" "https://api.sp
## $ analysis_url    : chr "https://api.spotify.com/v1/audio-analysis/7dTxqsaFGH0XwtzHINjfHv" "https:
## $ duration_ms     : num 191948 150827 145611 89509 280400 ...
## $ time_signature  : num 4 4 4 4 4 3 4 NA 4 4 ...
```

Inference:

- The dataset contains **10,080 observations** and **22 variables**, including both continuous and categorical attributes.
- Key continuous variables: `msPlayed`, `danceability`, `energy`, `tempo`, and `loudness`.
- Key categorical variables: `genre` and `artistName`.
- Some columns, such as `track_href`, `uri`, and `id`, are non-informative for analysis and can be removed.
- Missing values are present in critical columns like `danceability`, `energy`, and `tempo` (550 rows each).
- Data types are generally appropriate (e.g., numeric for continuous variables, character for categorical), but some categorical variables require standardization (e.g., `genre` and `artistName`).

1.3 Statistical Summary of Each Column:

```
# View a summary of each column (e.g., min, max, mean, etc.)
summary(spotify_data)
```

```
## trackName      artistName      msPlayed      genre
## Length:10080   Length:10080   Min. :      0   Length:10080
## Class :character Class :character 1st Qu.: 136780 Class :character
## Mode :character Mode :character Median : 266288 Mode :character
##               Mean : 1519657
##               3rd Qu.: 1186307
##               Max. :158367130
##
## danceability    energy          key          loudness
## Min. :0.0000    Min. :0.0011   Min. : 0.000   Min. : -42.044
## 1st Qu.:0.5090   1st Qu.:0.4030 1st Qu.: 2.000   1st Qu.: -10.189
## Median :0.6230   Median :0.5890 Median : 5.000   Median : -7.218
## Mean :0.6025     Mean :0.5635   Mean : 5.242     Mean : -8.685
## 3rd Qu.:0.7140   3rd Qu.:0.7510 3rd Qu.: 8.000   3rd Qu.: -5.336
## Max. :0.9760     Max. :0.9990   Max. :11.000     Max. : 3.010
## NA's :550        NA's :550      NA's :550        NA's :550
##
## mode           speechiness    acousticness    instrumentalness
## Min. :0.0000    Min. :0.0000   Min. :0.0000    Min. :0.0000
## 1st Qu.:0.0000   1st Qu.:0.0361 1st Qu.:0.0538   1st Qu.:0.0000
## Median :1.0000   Median :0.0479 Median :0.2450    Median :0.0000
## Mean :0.6124     Mean :0.0785   Mean :0.3629     Mean :0.1532
## 3rd Qu.:1.0000   3rd Qu.:0.0819 3rd Qu.:0.6680    3rd Qu.:0.0276
## Max. :1.0000     Max. :0.9660   Max. :0.9960     Max. :0.9930
## NA's :550        NA's :550      NA's :550        NA's :550
##
## liveness        valence          tempo          type
## Min. :0.0249     Min. :0.0000   Min. : 0.00     Length:10080
## 1st Qu.:0.0962   1st Qu.:0.2370 1st Qu.: 97.57   Class :character
## Median :0.1190   Median :0.4090 Median :119.82    Mode :character
## Mean :0.1746     Mean :0.4341   Mean :119.37
## 3rd Qu.:0.2090   3rd Qu.:0.6140 3rd Qu.:139.78
```

```
## Max.      :0.9640    Max.      :0.9860    Max.      :236.20
## NA's      :550      NA's      :550      NA's      :550
##      id              uri              track_href      analysis_url
## Length:10080      Length:10080      Length:10080      Length:10080
## Class :character   Class :character   Class :character   Class :character
## Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##      duration_ms      time_signature
## Min.      : 10027      Min.      :0.000
## 1st Qu.: 161697      1st Qu.:4.000
## Median : 194286      Median :4.000
## Mean   : 202931      Mean   :3.917
## 3rd Qu.: 229526      3rd Qu.:4.000
## Max.    :4581483      Max.    :5.000
## NA's    :550          NA's    :550
```

Inference:

- **Response Variable (msPlayed):**
 - Highly variable, with values ranging from **0** to **158,367,130 ms**.
 - Median playback time is **266,288 ms**, with a mean of approximately **1,519,657 ms**, suggesting potential outliers.
- **Continuous Variables:**
 - **danceability, energy, and tempo:**
 - * Distributions appear to range from minimal to maximum values, indicating diversity in song attributes.
 - * Missing values (550 rows) may affect modeling and require handling.
 - **loudness:**
 - * Negative mean and median values indicate quieter tracks overall, with some louder tracks present.
- **Categorical Variables:**
 - **genre:**
 - * A mix of general and specific genres, with missing or empty values recorded.
 - **artistName:**
 - * Significant variability, with some names potentially requiring standardization (e.g., handling special characters, whitespace).
- **Other Observations:**
 - Variables such as **id**, **uri**, and **track_href** are identifiers and do not contribute to the analysis.
 - Columns like **type** are constant and can be excluded.

With this understanding of the dataset's structure and attributes, the next step is to identify and select three continuous variables and two categorical variables that are most relevant for modeling. These selected predictors will form the foundation of our regression analysis, guiding feature engineering and model specification.

1.4 Select 3 Continuous and 2 Categorical Variables:

The selection of variables is a critical step in regression analysis, as it determines the predictors that will explain the variability in the response variable (`msPlayed`).

For continuous variables -

- Attributes with **high variability**.
- Strong **relevance** to playback time.
- Minimal **missing values**.

For categorical variables -

- Predictors with **sufficient representation** in the dataset.
- Potential **influence** on playback time based on domain knowledge.

This approach should ensure that the model captures key **patterns** and **interactions** in the data effectively.

1.4.1 Selection of Variables Let's start with the Continuous Variables:

```
# Response Variable
response_variable <- "msPlayed"

# Continuous Variables: Selecting based on variability and relevance

# Checking summary statistics of numeric variables to identify candidates
numeric_cols <- sapply(spotify_data, is.numeric)
numeric_summary <- summary(spotify_data[, numeric_cols])

# Displaying summary for analysis
print(numeric_summary)
```

```
##      msPlayed      danceability      energy      key
## Min.      : 0      Min. :0.0000      Min. :0.0011      Min. : 0.000
## 1st Qu.: 136780      1st Qu.:0.5090      1st Qu.:0.4030      1st Qu.: 2.000
## Median : 266288      Median :0.6230      Median :0.5890      Median : 5.000
## Mean   : 1519657      Mean   :0.6025      Mean   :0.5635      Mean   : 5.242
## 3rd Qu.: 1186307      3rd Qu.:0.7140      3rd Qu.:0.7510      3rd Qu.: 8.000
## Max.   :158367130      Max.   :0.9760      Max.   :0.9990      Max.   :11.000
##                                     NA's   :550      NA's   :550      NA's   :550
##      loudness      mode      speechiness      acousticness
## Min.   :-42.044      Min.   :0.0000      Min.   :0.0000      Min.   :0.0000
## 1st Qu.: -10.189      1st Qu.:0.0000      1st Qu.:0.0361      1st Qu.:0.0538
## Median : -7.218      Median :1.0000      Median :0.0479      Median :0.2450
## Mean   : -8.685      Mean   :0.6124      Mean   :0.0785      Mean   :0.3629
## 3rd Qu.: -5.336      3rd Qu.:1.0000      3rd Qu.:0.0819      3rd Qu.:0.6680
## Max.   :  3.010      Max.   :1.0000      Max.   :0.9660      Max.   :0.9960
## NA's   :550      NA's   :550      NA's   :550      NA's   :550
## instrumentalness      liveness      valence      tempo
```

```
## Min.      :0.0000   Min.      :0.0249   Min.      :0.0000   Min.      : 0.00
## 1st Qu.:0.0000   1st Qu.:0.0962   1st Qu.:0.2370   1st Qu.: 97.57
## Median :0.0000   Median :0.1190   Median :0.4090   Median :119.82
## Mean    :0.1532   Mean    :0.1746   Mean    :0.4341   Mean    :119.37
## 3rd Qu.:0.0276   3rd Qu.:0.2090   3rd Qu.:0.6140   3rd Qu.:139.78
## Max.    :0.9930   Max.    :0.9640   Max.    :0.9860   Max.    :236.20
## NA's    :550     NA's    :550     NA's    :550     NA's    :550
## duration_ms   time_signature
## Min.      : 10027   Min.      :0.000
## 1st Qu.: 161697   1st Qu.:4.000
## Median : 194286   Median :4.000
## Mean    : 202931   Mean    :3.917
## 3rd Qu.: 229526   3rd Qu.:4.000
## Max.    :4581483   Max.    :5.000
## NA's    :550     NA's    :550
```

Selected Variables: From the dataset, the following continuous variables stand out for their relevance to playback duration:

1. **Danceability:** How suitable a track is for dancing, with values ranging from 0 to 0.9760 (Mean: 0.6025).
2. **Energy:** A measure of intensity and activity, ranging from 0.0011 to 0.9990 (Mean: 0.5635).
3. **Tempo:** The track's pace in beats per minute, varying between 0 and 236.20 (Mean: 119.37).

Issues Identified:

- **Missing Values:** All three variables have 550 missing values that must be addressed before analysis.
- **Outliers:** Extremely low values in **tempo** (Min: 0) and **energy** (Min: 0.0011) may indicate errors or unusual cases that need review.
- **Scaling:** These variables might require normalization to ensure they contribute equally to the regression model.

Inference: These continuous variables provide meaningful insights into track characteristics and their influence on playback duration. However, careful preprocessing is crucial to handle missing data and outliers effectively, ensuring the reliability of the analysis.

With the continuous variables selected, the next step is to dive into the categorical variables, such as **genre** and **artistName**. These features can reveal trends and patterns that help explain playback duration from a categorical perspective. Let's explore their potential.

But before that, let's load the selected columns into a list

```
continuous_variables <- c("danceability", "energy", "tempo")
```

Now, let's look into the Categorical Variables -

```
# Categorical Variables: Identifying based on frequency distribution and relevance
# Analyzing the unique counts of categorical columns
categorical_cols <- sapply(spotify_data, is.character)
spotify_data %>%
  select(which(categorical_cols)) %>%
  summarise_all(~ length(unique(.)))
```

```
## trackName artistName genre type id uri track_href analysis_url
## 1 4815 2312 524 2 4737 4737 4737 4737
```

```
# Suggested Categorical Variables (based on analysis)
categorical_variables <- c("genre", "artistName")
```

Inference: The code analyzed the unique value counts of all categorical columns in the dataset to identify meaningful predictors. Among the categorical columns: - **genre** has 524 unique values, representing various music genres, making it a promising candidate for analysis. - **artistName** has 2,312 unique values, capturing a wide range of artists, which may provide insights into playback patterns. - Other columns such as **type**, **id**, **uri**, **track_href**, and **analysis_url** primarily contain identifiers or URLs with limited analytical relevance. These columns can be excluded from further analysis.

This analysis confirms that **genre** and **artistName** are the most relevant categorical variables for inclusion in the regression model. Their diversity offers potential for capturing patterns in playback duration, provided these categories are effectively cleaned and standardized.

Having identified **danceability**, **energy**, and **tempo** as the key continuous variables and **genre** and **artistName** as the critical categorical variables, the next step focuses on data cleaning. This involves handling missing values, addressing potential outliers, and standardizing categorical variables to ensure they are model-ready. Let's proceed with preparing these variables for the regression analysis.

2. Data Cleaning:

2.1 Handling Missing Values

Identifying Missing Values -

```
colSums(is.na(spotify_data))
```

```
## trackName artistName msPlayed genre
## 0 0 0 0
## danceability energy key loudness
## 550 550 550 550
## mode speechiness acousticness instrumentalness
## 550 550 550 550
## liveness valence tempo type
## 550 550 550 0
## id uri track_href analysis_url
## 0 0 0 0
## duration_ms time_signature
## 550 550
```

Observation: Columns like **danceability**, **energy**, **tempo**, and others have 550 missing values, while some columns have no missing values.

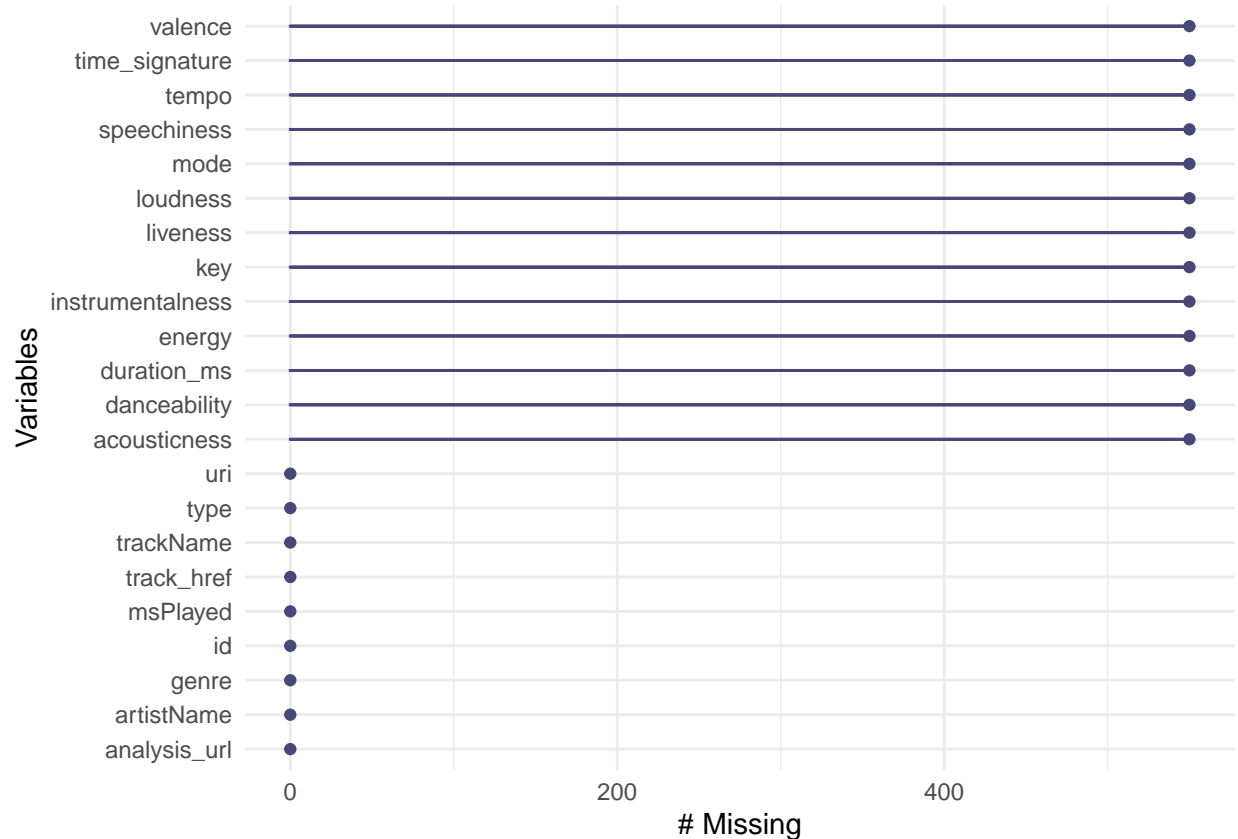
To handle the missing values, let's first try and analyse the missing value summary -

```
missing_summary <- colSums(is.na(spotify_data)) / nrow(spotify_data) * 100
print(missing_summary)
```

```
##      trackName      artistName      msPlayed      genre
##      0.000000      0.000000      0.000000      0.000000
##      danceability      energy      key      loudness
##      5.456349      5.456349      5.456349      5.456349
##      mode      speechiness      acousticness      instrumentalness
##      5.456349      5.456349      5.456349      5.456349
##      liveness      valence      tempo      type
##      5.456349      5.456349      5.456349      0.000000
##      id      uri      track_href      analysis_url
##      0.000000      0.000000      0.000000      0.000000
##      duration_ms      time_signature
##      5.456349      5.456349
```

Let's check for missing data patterns -

```
library(naniar)
gg_miss_var(spotify_data)
```



Inference: Our selected continuous variables—**danceability**, **energy**, and **tempo**—each have around 550 missing values, accounting for about 5.5% of the dataset. Since these variables are central to our regression analysis, removing rows with missing values would significantly reduce our sample size, potentially affecting the model's reliability.

To address this, we considered different imputation methods: - **Mean or Median Imputation** could fill the gaps but might distort the distribution, especially if the data is skewed. - **K-Nearest Neighbors (KNN)**

Imputation leverages similar observations to predict missing values, which helps maintain relationships within the data. - **Regression-Based Imputation** and **Multiple Imputation** are alternatives, but they can add complexity without necessarily improving the outcome for our purposes.

Given the balance between accuracy and practicality, **KNN imputation** is our chosen approach. It allows us to estimate missing values based on similarities in the dataset, preserving both data relationships and sample size for a more robust regression analysis.

Let's proceed with KNN imputation to handle the missing values in our continuous variables.

KNN Imputation for Missing Values:

```
# Specify the continuous variables with missing values
continuous_vars <- c("danceability", "energy", "tempo")

# Perform KNN imputation on the dataset for the specified columns
spotify_data_imputed <- kNN(spotify_data, variable = continuous_vars, k = 5)

# Check if missing values are handled
colSums(is.na(spotify_data_imputed))
```

```
##      trackName      artistName      msPlayed      genre
##           0           0           0           0
##  danceability      energy           key      loudness
##           0           0          550          550
##      mode      speechiness      acousticness      instrumentalness
##          550           550           550           550
##      liveness      valence           tempo           type
##          550           550           0           0
##      id      uri      track_href      analysis_url
##           0           0           0           0
##  duration_ms      time_signature      danceability_imp      energy_imp
##          550           550           0           0
##      tempo_imp
##           0
```

```
# View the structure and summary after imputation
str(spotify_data_imputed)
```

```
## 'data.frame': 10080 obs. of 25 variables:
## $ trackName : chr "\"Honest\"" "\"In The Hall Of The Mountain King\"" from Peer Gynt Suite N°
## $ artistName : chr "Nico Collins" "London Symphony Orchestra" "SyKo" "Good Morning" ...
## $ msPlayed : int 191772 1806234 145610 25058 5504949 2237969 441335 70589 120005 107407 ...
## $ genre : chr "" "british orchestra" "glitchcore" "experimental pop" ...
## $ danceability : num 0.476 0.475 0.691 0.624 0.625 0.645 0.663 0.636 0.792 0.759 ...
## $ energy : num 0.799 0.13 0.814 0.596 0.726 0.611 0.904 0.335 0.511 0.699 ...
## $ key : num 4 7 1 4 11 8 7 NA 2 0 ...
## $ loudness : num -4.94 -17.72 -3.79 -9.8 -11.4 ...
## $ mode : num 0 1 0 1 0 0 1 NA 1 0 ...
## $ speechiness : num 0.212 0.051 0.117 0.0314 0.0444 0.137 0.0857 NA 0.0409 0.0307 ...
## $ acousticness : num 0.0162 0.916 0.0164 0.475 0.0158 0.29 0.000708 NA 0.124 0.202 ...
## $ instrumentalness: num 0.00 9.56e-01 0.00 2.03e-01 1.69e-04 2.05e-05 2.89e-01 NA 9.04e-05 1.31e-04
## $ liveness : num 0.257 0.101 0.366 0.119 0.0625 0.237 0.341 NA 0.14 0.443 ...
## $ valence : num 0.577 0.122 0.509 0.896 0.507 0.645 0.675 NA 0.111 0.907 ...
```

```
## $ tempo      : num  162 112 132 121 125 ...
## $ type       : chr   "audio_features" "audio_features" "audio_features" "audio_features" ...
## $ id        : chr   "7dTxqsaFGHOXwtzHINjfHv" "14Qcrx6Dfjvcj0H8oV8oUW" "7K9Z3yFNNLv5kwTjQYGjnu"
## $ uri       : chr   "spotify:track:7dTxqsaFGHOXwtzHINjfHv" "spotify:track:14Qcrx6Dfjvcj0H8oV8oUW"
## $ track_href : chr   "https://api.spotify.com/v1/tracks/7dTxqsaFGHOXwtzHINjfHv" "https://api.spotify.com/v1/tracks/14Qcrx6Dfjvcj0H8oV8oUW"
## $ analysis_url : chr  "https://api.spotify.com/v1/audio-analysis/7dTxqsaFGHOXwtzHINjfHv" "https://api.spotify.com/v1/audio-analysis/14Qcrx6Dfjvcj0H8oV8oUW"
## $ duration_ms : num  191948 150827 145611 89509 280400 ...
## $ time_signature : num  4 4 4 4 4 3 4 NA 4 4 ...
## $ danceability_imp: logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ energy_imp     : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ tempo_imp      : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
```

```
summary(spotify_data_imputed[continuous_vars])
```

```
##    danceability      energy      tempo
##  Min.   :0.0000   Min.   :0.00108   Min.    : 0.00
## 1st Qu.:0.5170   1st Qu.:0.35200   1st Qu.: 99.02
## Median :0.6330   Median :0.56800   Median :120.02
## Mean   :0.6043   Mean   :0.55105   Mean   :119.95
## 3rd Qu.:0.7080   3rd Qu.:0.74000   3rd Qu.:137.77
## Max.   :0.9760   Max.   :0.99900   Max.    :236.20
```

With the continuous variables (`danceability`, `energy`, `tempo`) and their missing values successfully handled using KNN imputation, we have ensured the dataset's integrity while maintaining its structure. Additionally, the inclusion of indicator columns (`danceability_imp`, `energy_imp`, `tempo_imp`) allows us to trace imputed values and assess their impact on the analysis. To streamline our upcoming regression analysis, we will now create a reduced dataset containing only the essential columns: the response variable (`msPlayed`), selected predictors (`danceability`, `energy`, `tempo`, `genre`, and `artistName`), imputation indicators, and the `trackName` for identification. This focused dataset will simplify further processing while retaining all critical information.

```
# Extract the required columns for analysis, including imputation indicators
columns_needed <- c("trackName", "msPlayed", "danceability", "danceability_imp", "energy", "energy_imp")
spotify_analysis_data <- spotify_data_imputed %>% select(all_of(columns_needed))

# View the structure of the new dataset to confirm
str(spotify_analysis_data)
```

Code to Create Reduced Dataset

```
## 'data.frame':    10080 obs. of  10 variables:
## $ trackName      : chr   "\"Honest\"" "\"In The Hall Of The Mountain King\"" from Peer Gynt Suite No. 1, Op. 46, Act 1, Scene 1
## $ msPlayed       : int   191772 1806234 145610 25058 5504949 2237969 441335 70589 120005 107407 ...
## $ danceability    : num   0.476 0.475 0.691 0.624 0.625 0.645 0.663 0.636 0.792 0.759 ...
## $ danceability_imp: logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ energy          : num   0.799 0.13 0.814 0.596 0.726 0.611 0.904 0.335 0.511 0.699 ...
## $ energy_imp      : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ tempo          : num   162 112 132 121 125 ...
## $ tempo_imp       : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ genre           : chr   "" "british orchestra" "glitchcore" "experimental pop" ...
## $ artistName      : chr   "Nico Collins" "London Symphony Orchestra" "SyKo" "Good Morning" ...
```

```
# Display the first few rows of the new dataset
head(spotify_analysis_data)
```

```
##                                     trackName msPlayed
## 1                                     "Honest"   191772
## 2 "In The Hall Of The Mountain King" from Peer Gynt Suite N°1, Op. 46 1806234
## 3                                     #BrooklynBloodPop! 145610
## 4                                     $10         25058
## 5                                     (I Just) Died In Your Arms 5504949
## 6                                     (L)only Child 2237969
##  danceability danceability_imp energy energy_imp  tempo tempo_imp
## 1          0.476             FALSE 0.799      FALSE 162.139    FALSE
## 2          0.475             FALSE 0.130      FALSE 112.241    FALSE
## 3          0.691             FALSE 0.814      FALSE 132.012    FALSE
## 4          0.624             FALSE 0.596      FALSE 120.969    FALSE
## 5          0.625             FALSE 0.726      FALSE 124.945    FALSE
## 6          0.645             FALSE 0.611      FALSE 157.475    FALSE
##           genre                artistName
## 1                                Nico Collins
## 2 british orchestra London Symphony Orchestra
## 3          glitchcore                SyKo
## 4 experimental pop                Good Morning
## 5          album rock                Cutting Crew
## 6           alt z                  salem ilese
```

1. **Selection of Essential Columns:** Includes the predictors, response variable, imputation indicators, and trackName.
2. **Reduced Complexity:** Focuses on columns relevant to the regression analysis while excluding irrelevant or redundant columns.
3. **Output:** Saves the reduced dataset to a CSV file for ease of access in subsequent steps.

Key Observations:

1. Track Identifiers:

- **trackName:** This column contains the names of the tracks, which can serve as identifiers.

2. Response Variable:

- **msPlayed:** Represents the playback duration in milliseconds.

3. Continuous Predictors:

- **danceability, energy, tempo:** Key features relevant to predicting playback time.
- Associated imputation flags (**danceability_imp, energy_imp, tempo_imp**) indicate whether these values were imputed during the data preparation process.

4. Categorical Predictors:

- **genre and artistName:** These columns remain to be cleaned and standardized for use in the analysis.

Next Steps: With the core columns identified, the focus now shifts to cleaning and standardizing the categorical columns (**genre** and **artistName**) and handling potential inconsistencies in **trackName**. Proper cleaning ensures consistency and reliability in the regression model.

2.2 Categorical Column Cleaning and Standardization

2.2.1 Genre Column - The `genre` column, as one of the categorical variables in our dataset, represents the musical genre of tracks. However, it contains inconsistencies, missing values, and a wide variety of categories, some of which are rare. Cleaning and standardizing this column are critical to ensure it contributes meaningfully to the regression analysis. This involves addressing missing values, standardizing formats, grouping rare categories, and mapping values into broader, interpretable categories.

We now proceed to implement the cleaning and standardization of the `genre` column.

Step 1: Handling Missing and Empty Values Replacing empty or missing genres with a placeholder like “Unspecified Genre” to avoid data loss.

```
# Replacing empty genre values with "Unspecified Genre"
spotify_analysis_data$genre[spotify_analysis_data$genre == "" | is.na(spotify_analysis_data$genre)] <-
```

Step 2: Standardizing Genre Names Converting all genre names to lowercase for consistency.

```
# Converting genre names to lowercase
spotify_analysis_data$genre <- tolower(spotify_analysis_data$genre)
```

Step 3: Analyzing Genre Frequencies Checking the frequency of unique genres to identify rare categories for grouping.

```
# Displaying the frequency of genres
genre_counts <- sort(table(spotify_analysis_data$genre), decreasing = TRUE)
head(genre_counts, 25) # Display the top 25 genres
```

```
##
##      unspecified genre      alt z      pop
##      1500      656      602
##      filmi      dance pop      singer-songwriter pop
##      412      172      164
##      alternative metal      anime lo-fi      art pop
##      150      136      126
##      drift phonk      brostep modern alternative rock
##      124      116      112
##      lo-fi study      edm      anime
##      110      100      98
##      chill pop      classical      j-pop
##      94      92      92
##      cloud rap      la pop      modern rock
##      88      84      80
##      lo-fi sleep      boy band      lo-fi chill
##      74      72      70
##      baroque pop
##      68
```

Inference:

- **Unspecified Genre:**
 - Observed 1,500 entries with “Unspecified Genre,” indicating missing or unclear data that requires handling to avoid bias in the analysis.

- **Dominant Genres:**
 - Frequently occurring genres like “alt z” (656), “pop” (602), and “filmi” (412) dominate the dataset, highlighting their importance in analysis.
- **Rare Genres:**
 - Many genres, such as “baroque pop” (68) and “lo-fi chill” (70), have low representation, contributing to the long-tail distribution.
- **Genre Imbalance:**
 - The distribution of genres is imbalanced, with a few common categories and many rare ones, suggesting the need for grouping or consolidation.
- **Impact on Analysis:**
 - Cleaning and standardizing the genre column will ensure better interpretability, reduce sparsity, and improve the robustness of regression models by minimizing noise from rare categories.

To address the challenges identified in the genre column—unspecified genres, rare categories, and imbalanced representation—we’ll map existing genres to broader, standardized categories. This step enhances interpretability, consolidates similar categories, and ensures meaningful patterns are captured in our analysis. Let’s proceed with implementing the genre mapping.

Step 4: Mapping Genres into Broader Categories Using a predefined mapping to standardize genre values.

```
# # Applying mapping with recode
genre_mapping <- c(
  "alt z" = "alternative",
  "album rock" = "rock",
  "british orchestra" = "classical",
  "desi hip hop" = "hip hop",
  "bedroom r&b" = "r&b",
  "singer-songwriter pop" = "pop",
  "la pop" = "pop",
  "lo-fi chill" = "lo-fi",
  "orchestral soundtrack" = "classical",
  "comic" = "other",
  "alternative metal" = "metal",
  "deep underground hip hop" = "hip hop",
  "pop" = "pop",
  "classical" = "classical",
  "modern alternative rock" = "alternative",
  "scandipop" = "pop",
  "punjabi pop" = "pop",
  "folk-pop" = "folk",
  "acoustic pop" = "pop",
  "art pop" = "pop",
  "electronica" = "electronic",
  "dance pop" = "pop",
  "bedroom pop" = "pop",
  "chill r&b" = "r&b",
  "indian lo-fi" = "lo-fi",
  "instrumental post-rock" = "post-rock",
  "classic bollywood" = "bollywood",
  "afghan pop" = "pop",
```

```

"classic rock" = "rock",
"german soundtrack" = "classical",
"anime lo-fi" = "lo-fi",
"lo-fi study" = "lo-fi",
"dark r&b" = "r&b",
"modern indie pop" = "indie",
"pop edm" = "edm",
"uk contemporary r&b" = "r&b",
"emo rap" = "hip hop",
"classic pakistani pop" = "pop",
"japanese chillhop" = "chillhop",
"japanese vgm" = "vgm",
"anime" = "other",
"bhangra" = "indian",
"afrobeats" = "afrobeat",
"j-pop" = "asian pop",
"k-pop" = "asian pop"
)

```

```

# Applying mapping with recode
spotify_analysis_data$genre <- dplyr::recode(
  spotify_analysis_data$genre,
  "alt z" = "alternative",
  "album rock" = "rock",
  "british orchestra" = "classical",
  "desi hip hop" = "hip hop",
  "bedroom r&b" = "r&b",
  "singer-songwriter pop" = "pop",
  "la pop" = "pop",
  "lo-fi chill" = "lo-fi",
  "orchestral soundtrack" = "classical",
  "comic" = "other",
  "alternative metal" = "metal",
  "deep underground hip hop" = "hip hop",
  "pop" = "pop",
  "classical" = "classical",
  "modern alternative rock" = "alternative",
  "scandipop" = "pop",
  "punjabi pop" = "pop",
  "folk-pop" = "folk",
  "acoustic pop" = "pop",
  "art pop" = "pop",
  "electronica" = "electronic",
  "dance pop" = "pop",
  "bedroom pop" = "pop",
  "chill r&b" = "r&b",
  "indian lo-fi" = "lo-fi",
  "instrumental post-rock" = "post-rock",
  "classic bollywood" = "bollywood",
  "afghan pop" = "pop",
  "classic rock" = "rock",
  "german soundtrack" = "classical",
  "anime lo-fi" = "lo-fi",
)

```

```

"lo-fi study" = "lo-fi",
"dark r&b" = "r&b",
"modern indie pop" = "indie",
"pop edm" = "edm",
"uk contemporary r&b" = "r&b",
"emo rap" = "hip hop",
"classic pakistani pop" = "pop",
"japanese chillhop" = "chillhop",
"japanese vgm" = "vgm",
"anime" = "other",
"bhangra" = "indian",
"afrobeats" = "afrobeat",
"j-pop" = "asian pop",
"k-pop" = "asian pop"
)

```

```

# Apply mapping with a loop
for (key in names(genre_mapping)) {
  spotify_analysis_data$genre[spotify_analysis_data$genre == key] <- genre_mapping[key]
}

```

To ensure the dataset remains focused on meaningful categories and avoids overcomplicating the analysis with rare genres, we now address infrequent genres by grouping them into a broader “Other” category. This step simplifies the genre distribution and strengthens the interpretability of our analysis. Let’s proceed with grouping these rare genres.

Step 5: Grouping Rare Categories Combine rare genres into an “Other” category based on frequency.

```

# Group genres with fewer than a threshold into "Other"
threshold <- 50 # Define the threshold
rare_genres <- names(genre_counts[genre_counts < threshold])
spotify_analysis_data$genre <- ifelse(spotify_analysis_data$genre %in% rare_genres, "Other", spotify_an

```

Step 6: Verify Cleaning Checking the cleaned genre column for consistency.

```

# Verify the updated genre column
unique_genres <- unique(spotify_analysis_data$genre)
print(unique_genres)

```

```

## [1] "unspecified genre"      "classical"
## [3] "Other"                  "rock"
## [5] "alternative"            "cloud rap"
## [7] "pop"                    "hip hop"
## [9] "lo-fi sleep"            "lo-fi"
## [11] "other"                  "metal"
## [13] "anime score"            "folk"
## [15] "filmi"                  "vgm"
## [17] "electronic"             "boy band"
## [19] "edm"                    "gen z singer-songwriter"
## [21] "post-rock"              "baroque pop"
## [23] "desi pop"               "bollywood"
## [25] "chill pop"              "brostep"
## [27] "asian pop"              "indie"

```

```
## [29] "indian"           "afrobeat"
## [31] "modern rock"      "canadian pop"
## [33] "icelandic indie"  "drift phonk"
## [35] "sad lo-fi"        "alternative dance"
```

After verifying the cleaning process for the `genre` column, we noticed an unexpected overlap between categories like "other" and "unspecified genre". Addressing these overlaps is essential to maintain consistency and avoid redundancy in our analysis. This step ensures that our categorical variable truly reflects distinct and meaningful groupings, paving the way for cleaner insights in the later stages.

```
# Combine "other" and "unspecified genre" into a single category "Other"
spotify_analysis_data$genre <- ifelse(
  spotify_analysis_data$genre %in% c("other", "unspecified genre"),
  "Other",
  spotify_analysis_data$genre
)

# Reassess the updated genre distribution
genre_counts_updated <- sort(table(spotify_analysis_data$genre), decreasing = TRUE)
head(genre_counts_updated, 25) # Display the top 25 genres
```

Resolving Overlaps in the Genre Column

```
##
##          Other          pop          alternative
##          5136          1300          768
##          filmi          lo-fi          classical
##          412           318           178
##          hip hop          metal          drift phonk
##          178           150           124
##          asian pop          edm          brostep
##          122           122           116
##          chill pop          cloud rap          modern rock
##          94            88            80
##          lo-fi sleep          boy band          baroque pop
##          74            72            68
##          indie          icelandic indie          desi pop
##          68            66            64
##          rock          alternative dance gen z singer-songwriter
##          64            62            62
##          anime score
##          58
```

Inference: Managing the Large “Other” Category

- **Observation:** A significant portion of songs (4,726 entries) fall under the "Other" category, highlighting potential overgeneralization of infrequent genres.
- **Implications:**
 - While simplifying the dataset, this grouping may obscure insights from rare genres that could influence playback time (`msPlayed`).

- Retaining more genre-specific details could enhance the interpretability and predictive power of the model.
- **Action:**
 - Refine the threshold for grouping into "Other".
 - Explore the distribution within "Other" to identify recurring patterns or clusters of genres that can be reclassified.
 - Balance simplification with information retention for optimal model performance.

To address the overgeneralization caused by the "Other" category, we can refine the threshold and explore patterns within the grouped entries. This step ensures a more meaningful representation of genre diversity in the dataset, improving the quality of subsequent analyses.

Given the current project's focus and time constraints, we have decided to proceed with the current genre grouping without further refinement. Refining "Other" into more granular categories remains a potential improvement and will be included in the **Future Works** section. Now, we move on to cleaning and preparing the `artistName` column to ensure its consistency and usability in the analysis.

2.2.2 ArtistName Column: The `artistName` column is critical for identifying key patterns and trends related to song playback. Cleaning this column involves:

1. **Removing whitespace:** Ensuring no leading or trailing spaces exist.
2. **Handling special characters:** Standardizing entries with special characters.
3. **Converting to lowercase:** Ensuring uniformity.
4. **Grouping rare artists:** Combining less frequent artists into an "Other" category to reduce categorical complexity.

Step 1: Remove Whitespace

```
# Remove leading and trailing whitespace in artistName
spotify_analysis_data$artistName <- trimws(spotify_analysis_data$artistName)

# Check for whitespace issues after cleaning
any(grepl("^\\s|\\s$", spotify_analysis_data$artistName)) # Should return FALSE
```

```
## [1] FALSE
```

Step 2: Handle Special Characters

```
# Identifying and display entries with special characters
special_characters <- spotify_analysis_data$artistName[grepl("[^a-zA-Z0-9\\s]", spotify_analysis_data$artistName)]
cat("Total entries with special characters:", length(special_characters), "\n")
```

```
## Total entries with special characters: 6386
```

```
head(special_characters, 10)
```

```
## [1] "Nico Collins"          "London Symphony Orchestra"
## [3] "Good Morning"         "Cutting Crew"
## [5] "salem ilese"          "Eren Cannata"
## [7] "$uicideboy$"          "Britney Spears"
## [9] "Sidhu Moose Wala"     "colours in the dark"
```

```
# Replacing specific special characters (e.g., "$" with "s")
spotify_analysis_data$artistName <- gsub("\\$", "s", spotify_analysis_data$artistName)
```

Step 3: Convert to Lowercase

```
# Converting artist names to lowercase for uniformity
spotify_analysis_data$artistName <- tolower(spotify_analysis_data$artistName)

# Verifying conversion
any(grepl("[A-Z]", spotify_analysis_data$artistName)) # Should return FALSE
```

```
## [1] FALSE
```

Step 4: Group Rare Artists into “Other”

```
# Defining threshold for grouping rare artists
artist_threshold <- 10 # Artists appearing fewer than this count will be grouped
artist_counts <- table(spotify_analysis_data$artistName)
rare_artists <- names(artist_counts[artist_counts < artist_threshold])

# Group rare artists into "Other"
spotify_analysis_data$artistName <- ifelse(spotify_analysis_data$artistName %in% rare_artists, "Other",

# Verify distribution after grouping
artist_counts_after <- table(spotify_analysis_data$artistName)
head(sort(artist_counts_after, decreasing = TRUE), 20) # Display top 20 artist counts
```

```
##
##          Other          blackbear          lauv          linkin park
##          6208           128           100           94
## the neighbourhood          kato          lund          radwimps
##          86            78            78            76
##          sonu nigan          low roar          mokita  vampire weekend
##          76            72            68            68
##          alec benjamin  charlie puth          hans zimmer          kk
##          66            66            66            64
## sasha alex sloan          pritam          skrillex  hiroyuki sawano
##          62            60            58            52
```

```
# Converting artistName to a factor for regression analysis
spotify_analysis_data$artistName <- as.factor(spotify_analysis_data$artistName)

# Verifying conversion
str(spotify_analysis_data$artistName)
```

Step 5: Convert to Factor

```
## Factor w/ 177 levels "5 seconds of summer",...: 126 132 132 132 132 132 132 123 132 132 ...
```

Inference

- Whitespace and special characters are cleaned, ensuring consistent formatting.
- Rare artists are grouped into an "Other" category, reducing the complexity of the categorical variable.
- The column is now ready for analysis as a factor variable.

With the `artistName` column successfully cleaned and prepared, we now focus on refining the continuous variables in our dataset. This involves addressing potential outliers to minimize their influence on regression models and standardizing these variables to ensure comparability. Let's begin with **outlier handling** for `danceability`, `energy`, and `tempo`.

2.3 Outlier Handling for Continuous Variables

Outliers in `danceability`, `energy`, and `tempo` can significantly impact regression analysis, leading to biased or unreliable results. We'll identify and handle these outliers using the **IQR method**.

```
# Define a function to identify outliers using the IQR method
identify_outliers <- function(column) {
  Q1 <- quantile(column, 0.25, na.rm = TRUE) # 25th percentile
  Q3 <- quantile(column, 0.75, na.rm = TRUE) # 75th percentile
  IQR <- Q3 - Q1 # Interquartile range
  lower_bound <- Q1 - 1.5 * IQR # Lower bound
  upper_bound <- Q3 + 1.5 * IQR # Upper bound
  list(lower = lower_bound, upper = upper_bound)
}

# Check outliers for continuous variables
outlier_bounds <- lapply(spotify_analysis_data[, c("danceability", "energy", "tempo")], identify_outliers)

# Print bounds
print(outlier_bounds)
```

Step 1: Identifying Outliers

```
## $danceability
## $danceability$lower
## 25%
## 0.2305
##
## $danceability$upper
## 75%
## 0.9945
##
##
## $energy
## $energy$lower
## 25%
## -0.23
##
## $energy$upper
```

```
##    75%
## 1.322
##
##
## $tempo
## $tempo$lower
##    25%
## 40.89775
##
## $tempo$upper
##    75%
## 195.8918
```

Interpretation:

1. Danceability:

- **Lower threshold:** 0.2305
- **Upper threshold:** 0.9945
- **Outliers:** Any values below 0.2305 or above 0.9945 are considered potential outliers.

2. Energy:

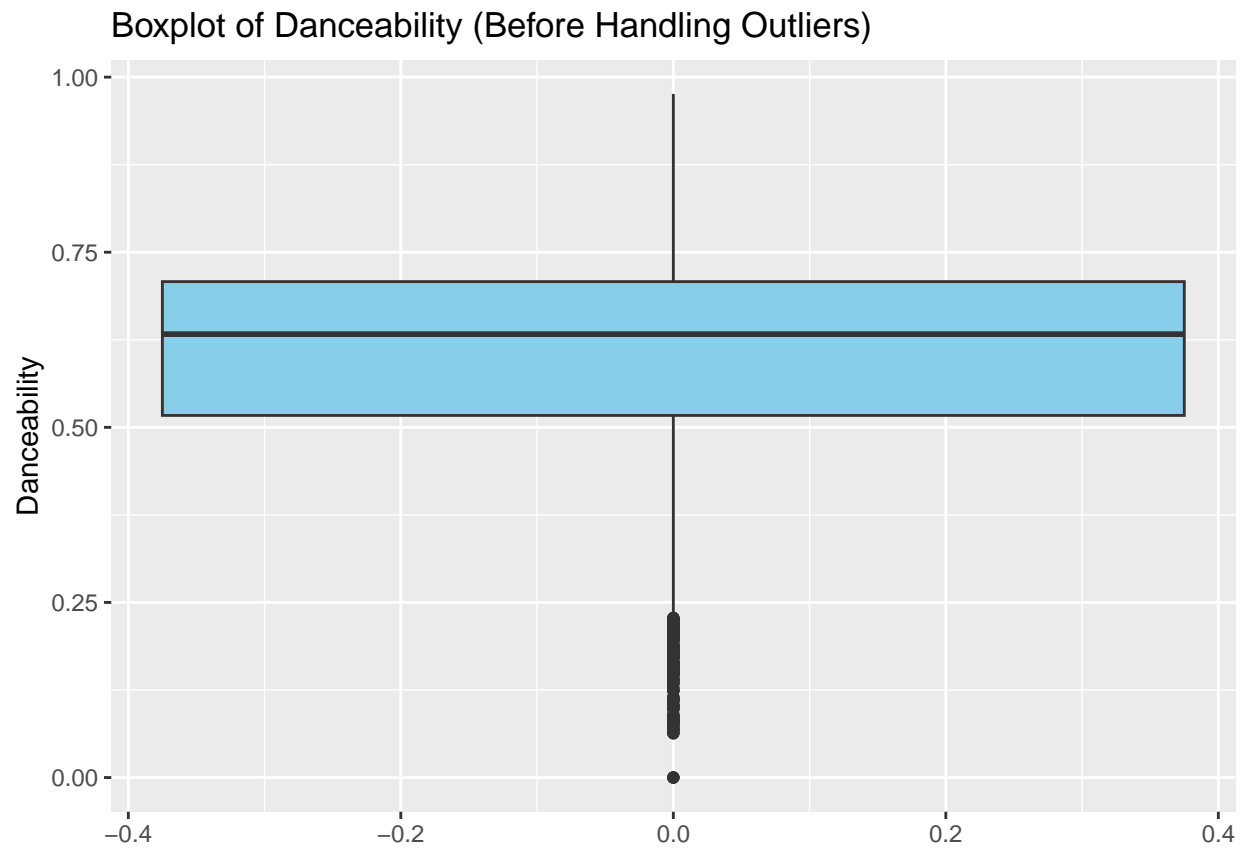
- **Lower threshold:** -0.23
- **Upper threshold:** 1.322
- **Outliers:** Any values below -0.23 or above 1.322 are considered potential outliers.

3. Tempo:

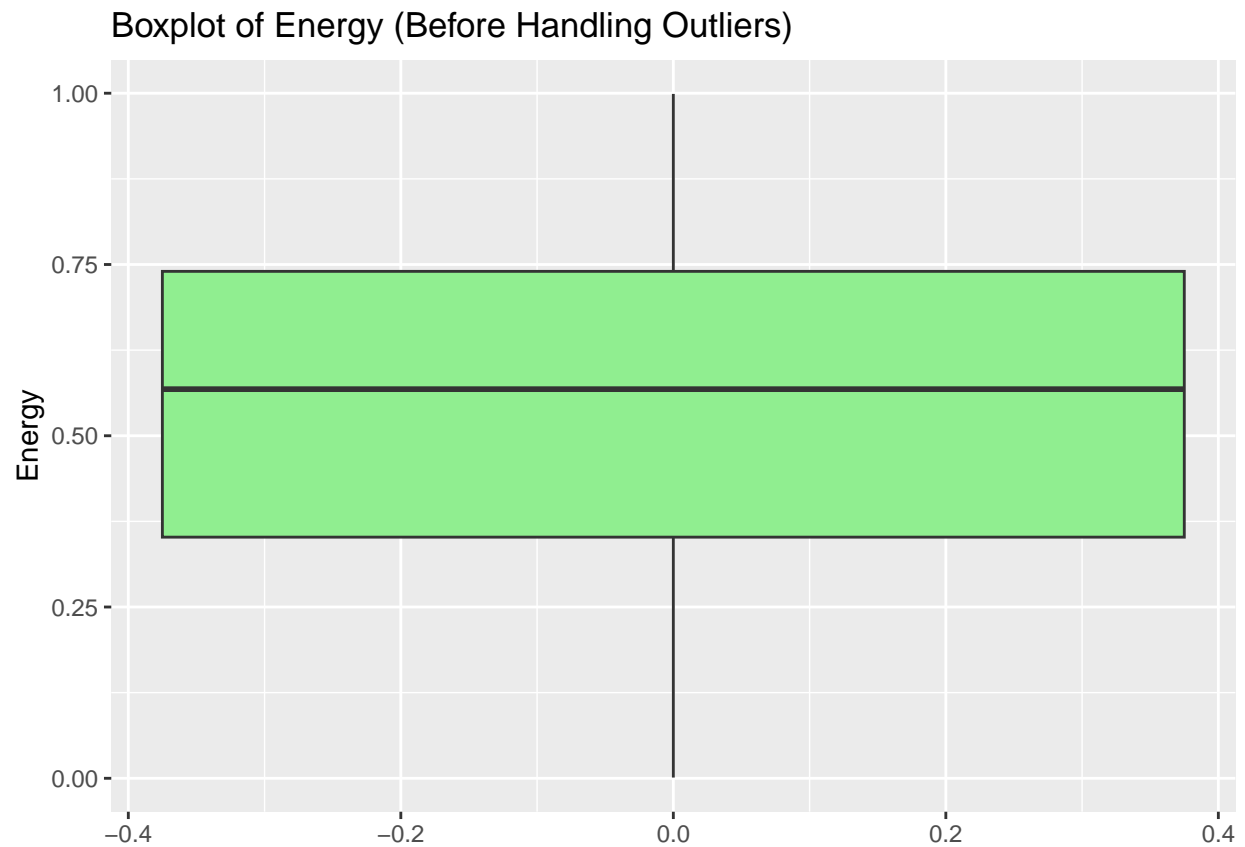
- **Lower threshold:** 40.89775
- **Upper threshold:** 195.8918
- **Outliers:** Any values below 40.89775 or above 195.8918 are considered potential outliers.

Let's now perform- **Visualization** of these outliers: - Highlight outliers in the visualizations (boxplots).

```
ggplot(spotify_analysis_data, aes(y = danceability)) +
  geom_boxplot(fill = "skyblue") +
  labs(title = "Boxplot of Danceability (Before Handling Outliers)", y = "Danceability")
```

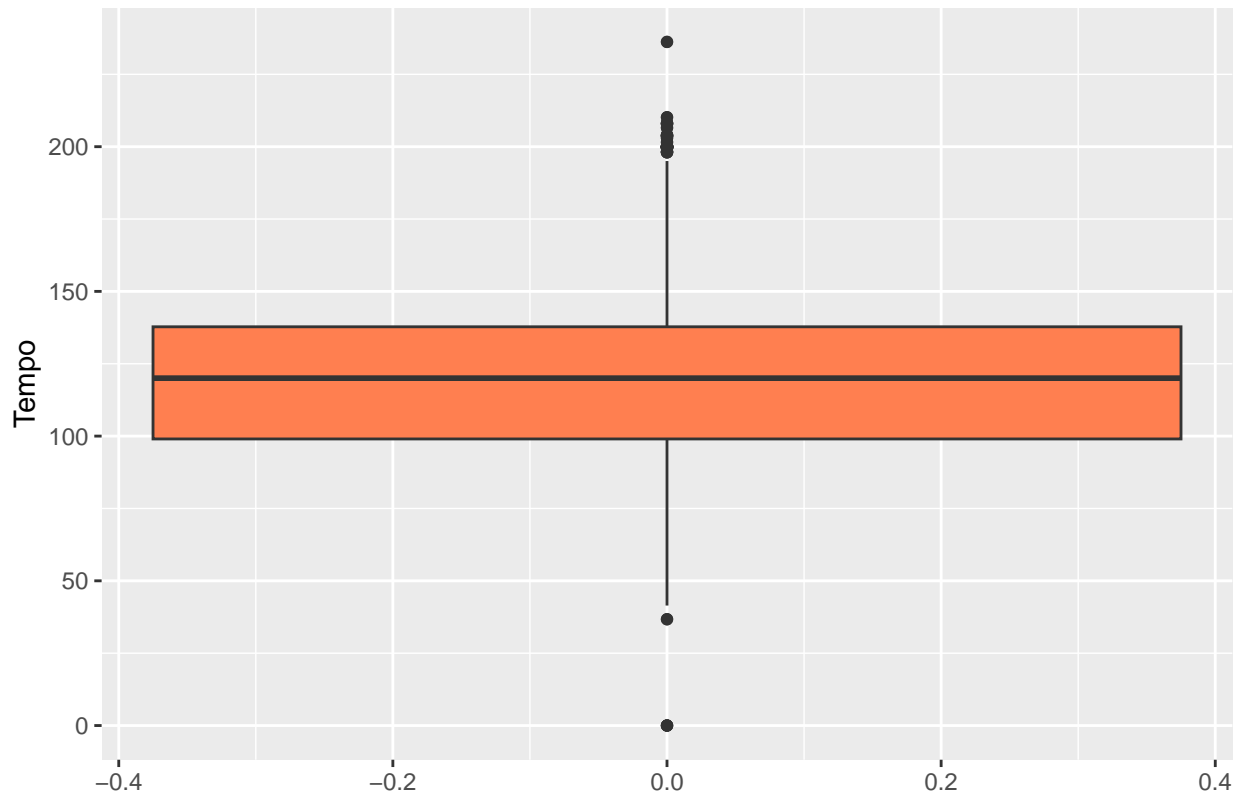



```
ggplot(spotify_analysis_data, aes(y = energy)) +  
  geom_boxplot(fill = "lightgreen") +  
  labs(title = "Boxplot of Energy (Before Handling Outliers)", y = "Energy")
```



```
ggplot(spotify_analysis_data, aes(y = tempo)) +  
  geom_boxplot(fill = "coral") +  
  labs(title = "Boxplot of Tempo (Before Handling Outliers)", y = "Tempo")
```

Boxplot of Tempo (Before Handling Outliers)



Step 2: Handle Outliers Options for handling outliers include: - **Capping**: Replace outliers with the nearest acceptable value within the bounds. - **Removing**: Remove rows containing outliers.

Here, we cap the outliers to ensure data retention.

```
# Defining a function to calculate outlier bounds
identify_outliers <- function(column) {
  iqr <- IQR(column, na.rm = TRUE)
  q1 <- quantile(column, 0.25, na.rm = TRUE)
  q3 <- quantile(column, 0.75, na.rm = TRUE)
  lower_bound <- q1 - 1.5 * iqr
  upper_bound <- q3 + 1.5 * iqr
  return(list(lower = lower_bound, upper = upper_bound))
}

# Defining a function to cap outliers
cap_outliers <- function(column, bounds) {
  column <- ifelse(column < bounds$lower, bounds$lower, column)
  column <- ifelse(column > bounds$upper, bounds$upper, column)
  return(column)
}

# Applying capping to the continuous variables
for (col in c("danceability", "energy", "tempo")) {
  # Calculate bounds
  bounds <- identify_outliers(spotify_analysis_data[[col]])
```

```
# Cap outliers
spotify_analysis_data[[col]] <- cap_outliers(spotify_analysis_data[[col]], bounds)
}
```

```
# Verifying outlier handling
summary(spotify_analysis_data[, c("danceability", "energy", "tempo")])
```

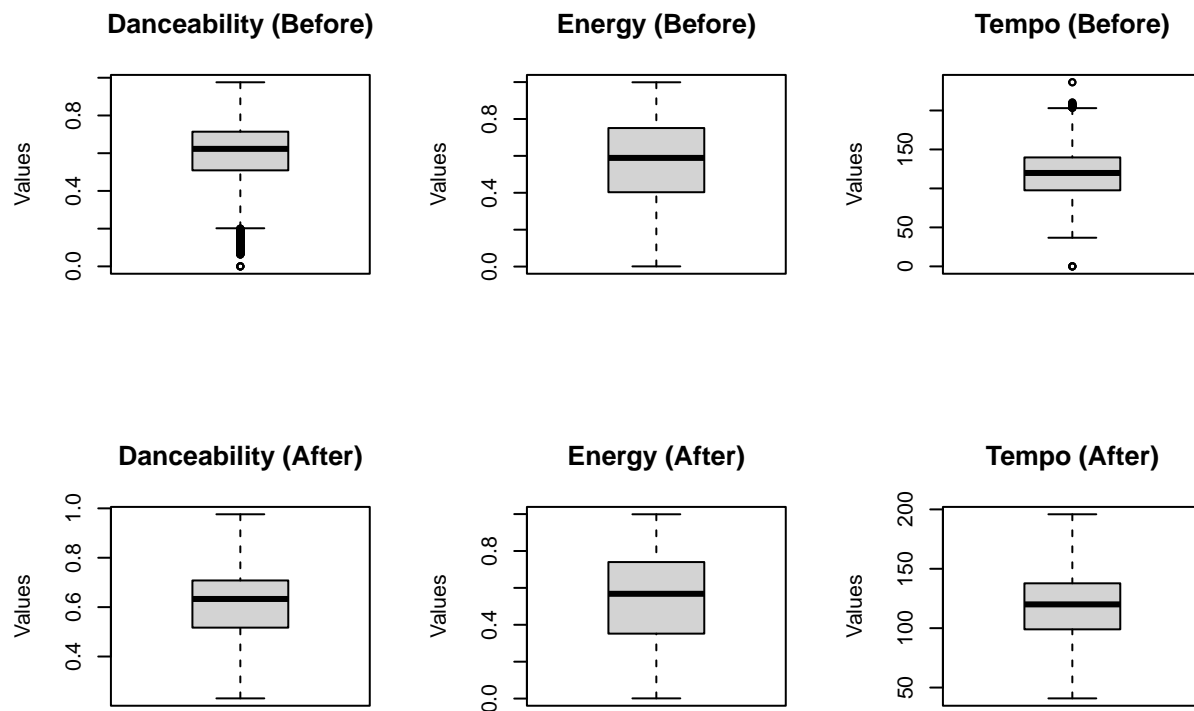
```
##  danceability      energy      tempo
##  Min.   :0.2305    Min.   :0.00108  Min.   : 40.90
##  1st Qu.:0.5170    1st Qu.:0.35200  1st Qu.: 99.02
##  Median :0.6330    Median :0.56800  Median :120.02
##  Mean   :0.6061    Mean   :0.55105  Mean   :119.93
##  3rd Qu.:0.7080    3rd Qu.:0.74000  3rd Qu.:137.77
##  Max.   :0.9760    Max.   :0.99900  Max.   :195.89
```

Visualisation -

```
# Visualizing outliers before and after capping using boxplots
par(mfrow = c(2, 3)) # Set layout for 3 variables before and after

# Before Capping
boxplot(data$danceability, main = "Danceability (Before)", ylab = "Values")
boxplot(data$energy, main = "Energy (Before)", ylab = "Values")
boxplot(data$tempo, main = "Tempo (Before)", ylab = "Values")

# After Capping
boxplot(spotify_analysis_data$danceability, main = "Danceability (After)", ylab = "Values")
boxplot(spotify_analysis_data$energy, main = "Energy (After)", ylab = "Values")
boxplot(spotify_analysis_data$tempo, main = "Tempo (After)", ylab = "Values")
```



Inference on Outlier Handling

The outlier capping process successfully addressed extreme values in the **danceability** and **tempo** columns, leading to a more stable dataset for further analysis. This ensures that: - **Data retention** is maintained by keeping all observations while reducing the impact of outliers. - The **distribution** of these variables is now more consistent, minimizing the potential influence of extreme values on the model. - **Energy** had few initial outliers, so this variable's distribution remains mostly unchanged, reflecting that the majority of values were within acceptable bounds.

This step contributes to a cleaner dataset that's better suited for regression analysis, as it reduces noise from extreme values that could skew insights and predictions.

With outliers addressed, the next logical step is to **normalize the continuous variables**—such as **danceability**, **energy**, and **tempo**—to ensure they're on a comparable scale. Normalization is important for regression analysis, as it allows each variable to contribute equally to the model without one variable disproportionately influencing the results due to its scale.

2.4 Normalization/ Scaling of Variables-

To normalize the continuous variables, we'll scale them to a range between 0 and 1 using Min-Max normalization. Here's the code to perform this step:

```
# Define a function for Min-Max normalization
normalize <- function(column) {
  return((column - min(column)) / (max(column) - min(column)))
}

# Apply normalization to the continuous variables
```

```
spotify_analysis_data$danceability <- normalize(spotify_analysis_data$danceability)
spotify_analysis_data$energy <- normalize(spotify_analysis_data$energy)
spotify_analysis_data$tempo <- normalize(spotify_analysis_data$tempo)

# Verify normalization
summary(spotify_analysis_data[, c("danceability", "energy", "tempo")])
```

```
##  danceability      energy      tempo
##  Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.3843   1st Qu.:0.3517   1st Qu.:0.3750
##  Median :0.5399   Median :0.5681   Median :0.5105
##  Mean   :0.5038   Mean   :0.5511   Mean   :0.5099
##  3rd Qu.:0.6405   3rd Qu.:0.7405   3rd Qu.:0.6250
##  Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
```

Inference After Normalization The normalization has been successfully applied to the continuous variables (`danceability`, `energy`, and `tempo`). Now, each of these variables is scaled between 0 and 1, as seen from the summary statistics. This transformation makes the dataset ready for further analysis, ensuring that the scales of these variables do not disproportionately influence the results.

3.Exploratory Data Analysis (EDA)

With the data now cleaned, normalized, and ready, we proceed to **Exploratory Data Analysis**. This phase focuses on uncovering patterns, relationships, and insights within the dataset that can inform our regression modeling. Specifically, we aim to:

1. **Visualize Distributions:** Plot the distributions of continuous and categorical variables to understand their spread and identify potential anomalies or patterns.
2. **Perform Correlation Analysis:** Explore relationships among continuous variables, with a focus on their impact on the response variable, `msPlayed`.
3. **Analyze Categorical Variables:** Investigate the influence of categorical variables (`genre` and `artistName`) on `msPlayed`.
4. **Bivariate Analysis:** Examine pairwise relationships between predictors and `msPlayed` using scatter-plots and boxplots.

3.1. Starting with Visualizing Distributions:

We first visualize the distributions of the continuous variables (`msPlayed`, `danceability`, `energy`, `tempo`) to assess their spread and identify any potential skewness. Then, we analyze the categorical variables (`genre` and `artistName`) to understand their representation and significance in the dataset.

```
# Visualize distributions of continuous variables
continuous_vars <- c("msPlayed", "danceability", "energy", "tempo")

for (var in continuous_vars) {
  print(
    ggplot(spotify_analysis_data, aes_string(var)) +
      geom_histogram(bins = 30, fill = "skyblue", color = "black") +
```

```

ggtitle(paste("Distribution of", var)) +
xlab(var) +
ylab("Frequency") +
theme_minimal()
)
}

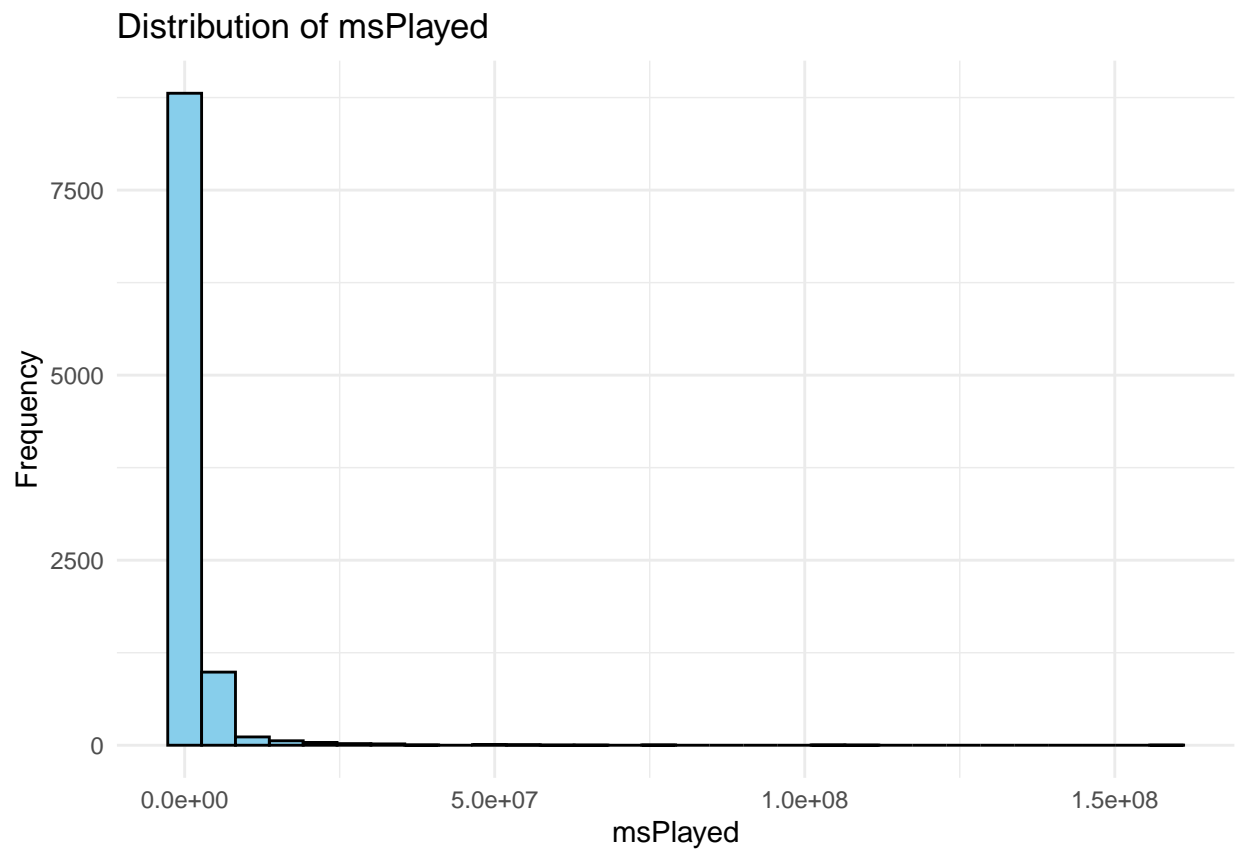
```

3.1.1 Continuous Variable Distributions:

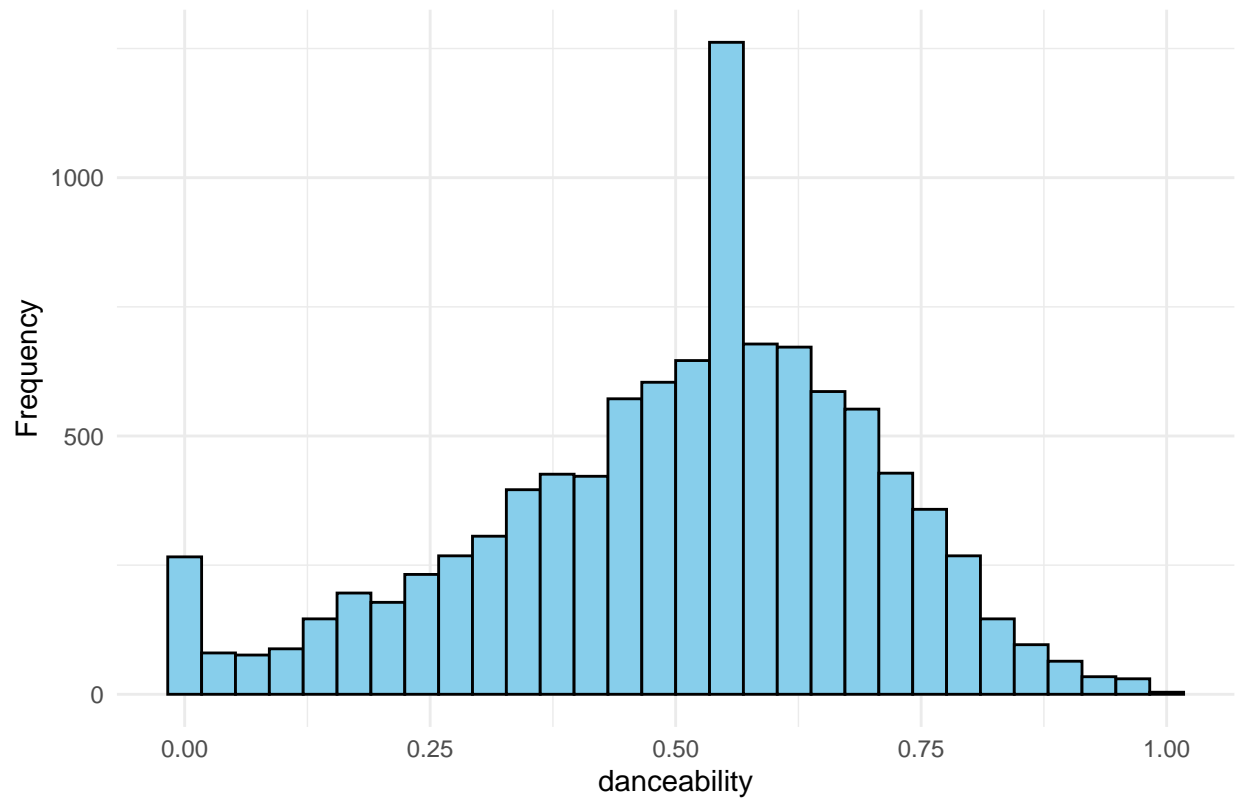
```

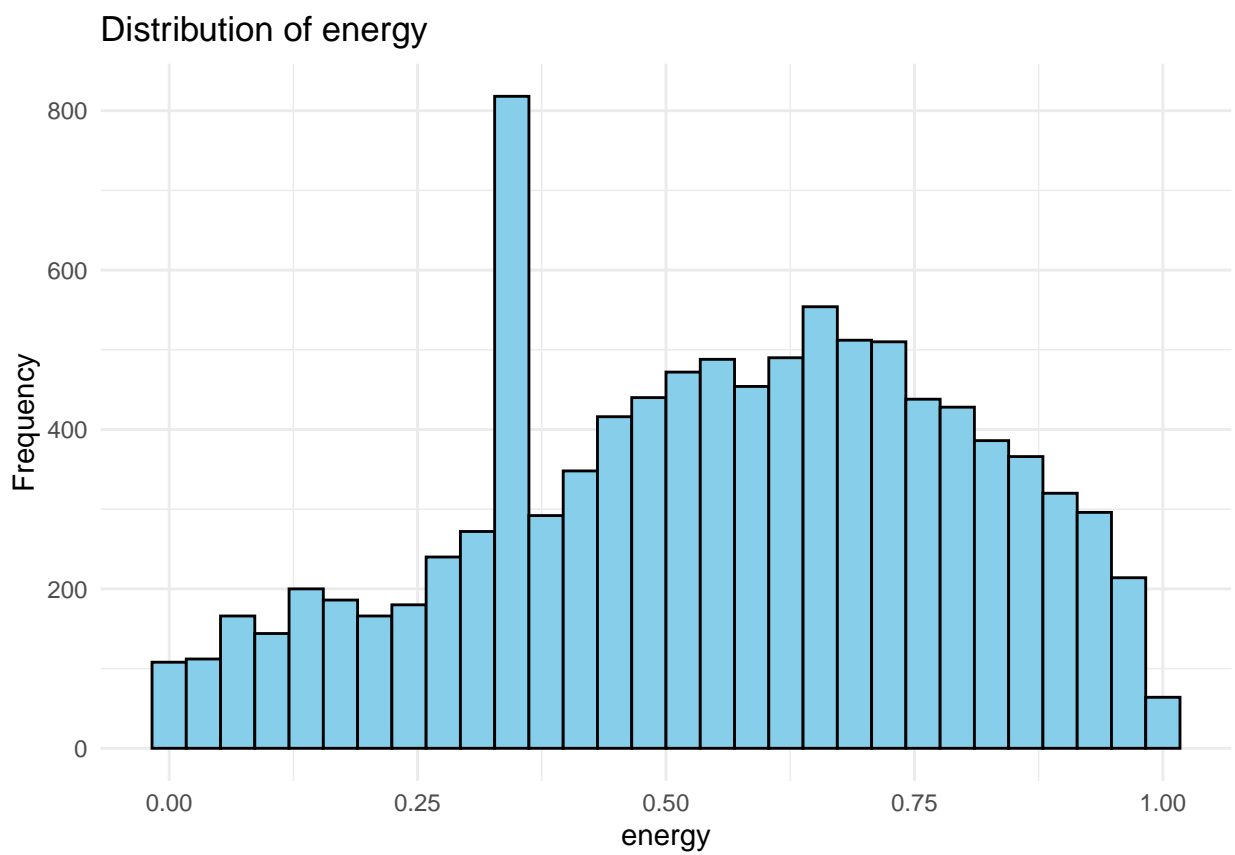
## Warning: 'aes_string()' was deprecated in ggplot2 3.0.0.
## i Please use tidy evaluation idioms with 'aes()'.
## i See also 'vignette("ggplot2-in-packages")' for more information.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.

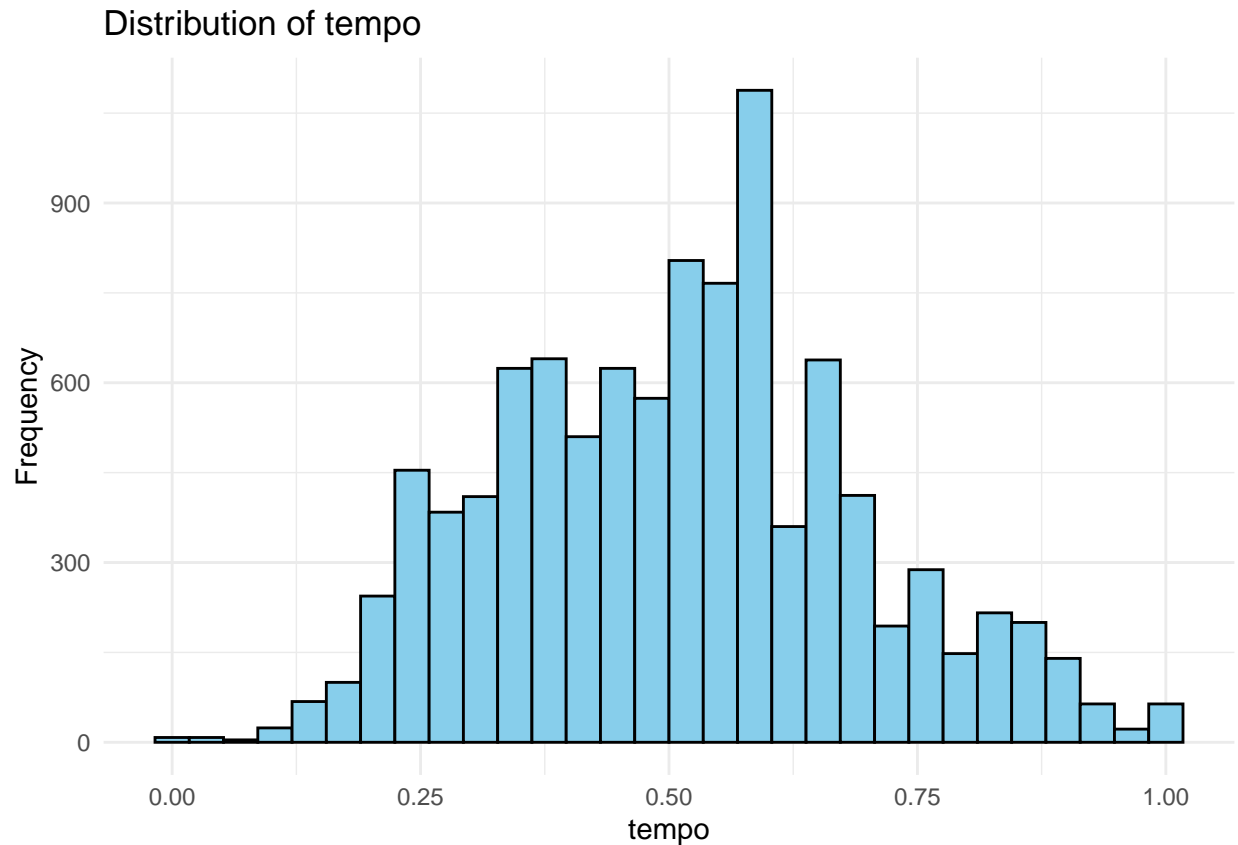
```



Distribution of danceability





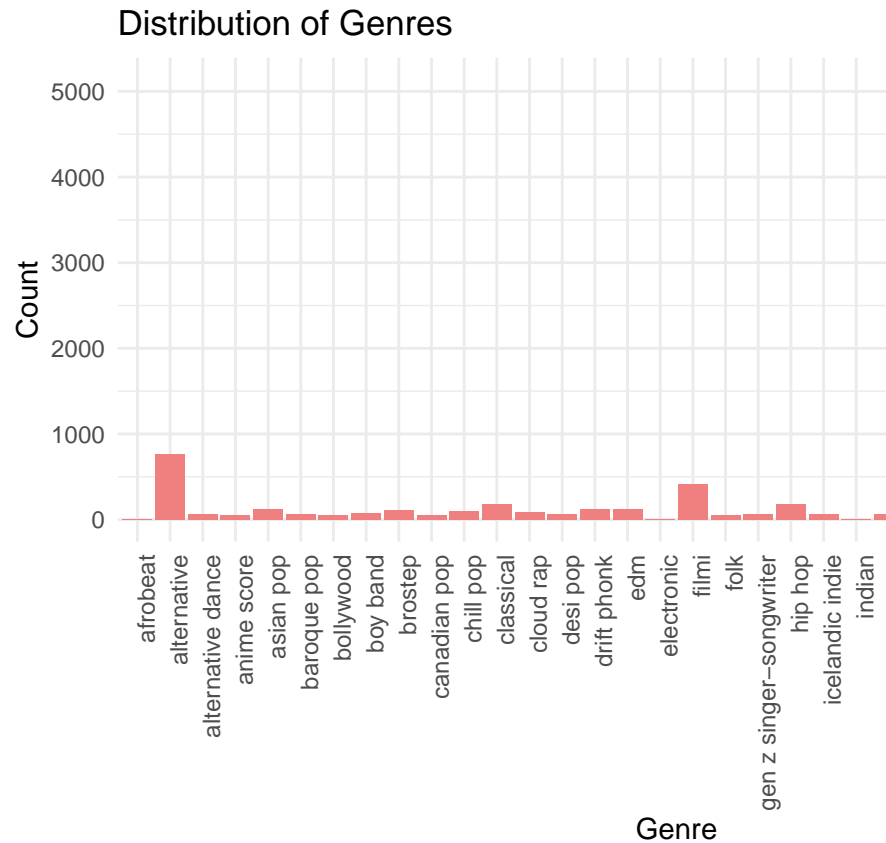


Interpretation:

- **msPlayed:** The distribution is right-skewed, suggesting most songs have shorter playback times, with a few high-duration outliers.
- **danceability, energy, and tempo:** These variables display balanced distributions post-normalization, which makes them suitable for further analysis in relation to the response variable.

With the continuous variable distributions examined, Let's now have a look at the Categorical Variable Distribution. we'll then conduct correlation analysis to understand relationships among features and with msPlayed. This step will guide feature selection and help identify any multicollinearity issues for our regression model.

```
# Genre Distribution
ggplot(spotify_analysis_data, aes(x = genre)) +
  geom_bar(fill = "lightcoral") +
  xlab("Genre") +
  ylab("Count") +
  ggtitle("Distribution of Genres") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```

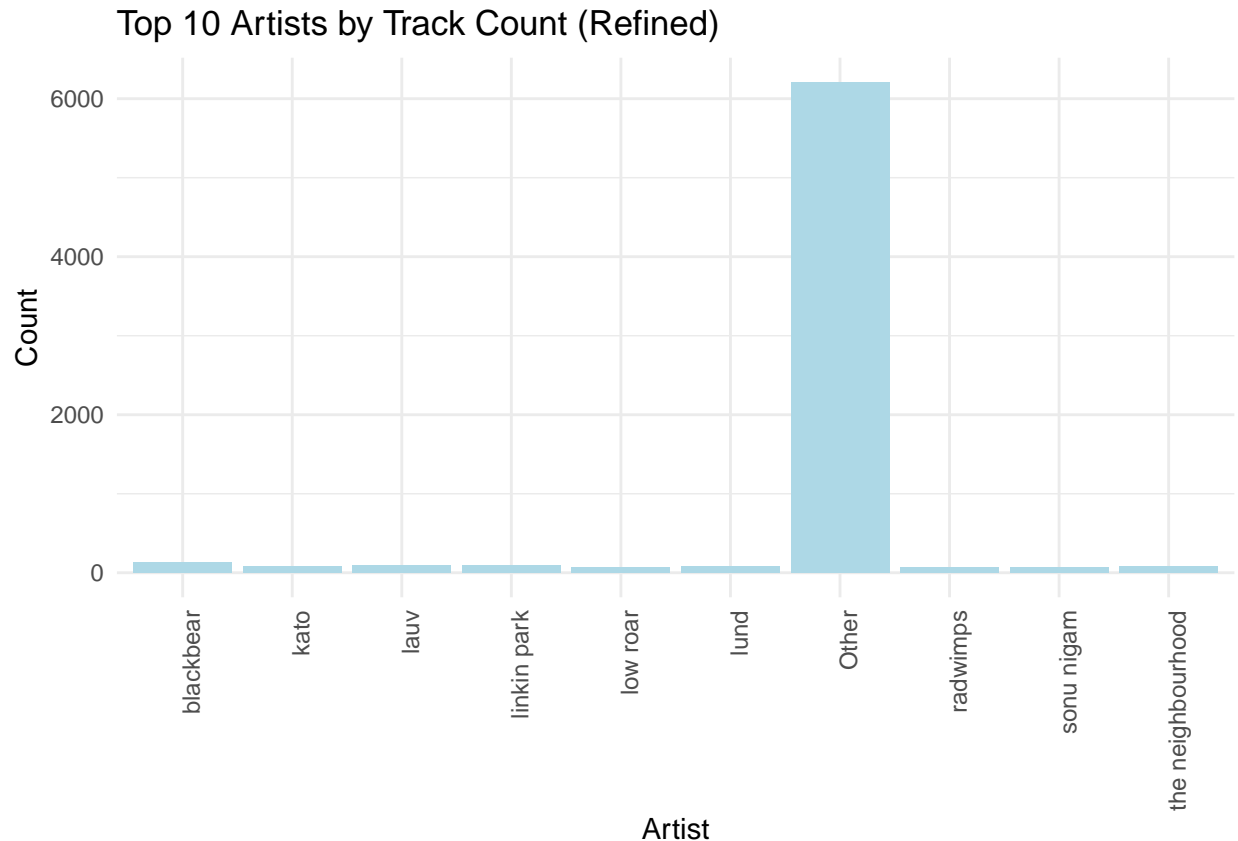


3.1.2 Categorical Variable Distributions:

```
# Convert artistName back to character to display names
spotify_analysis_data$artistName <- as.character(spotify_analysis_data$artistName)

# Filter for the top 10 artists by track count
top_artists <- names(sort(table(spotify_analysis_data$artistName), decreasing = TRUE))[1:10]
filtered_data <- spotify_analysis_data %>% filter(artistName %in% top_artists)

# Plot Top 10 Artists by Track Count
ggplot(filtered_data, aes(x = artistName)) +
  geom_bar(fill = "lightblue") +
  xlab("Artist") +
  ylab("Count") +
  ggtitle("Top 10 Artists by Track Count (Refined)") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



It is evident that in our dataset, the “**Other**” category represents a large and diverse set of genres and artists that appear infrequently. While this grouping helped simplify initial processing, it may introduce unnecessary complexity in the analysis phase. By retaining only the most frequent genres and artists, we ensure:

- **Focus on Significant Groups:** Analyzing the top genres and artists directly contributes to more targeted insights, as these groups are likely to have substantial representation and influence on the `msPlayed` variable.
- **Reduced Noise:** The “Other” category can introduce noise, diluting patterns that might emerge more distinctly without it.
- **Enhanced Interpretability:** Without the ambiguous “Other” category, our analysis can be more straightforward and insightful, focusing only on genres and artists with clearer identities.

Therefore, we proceed by filtering out rows where `genre` or `artistName` is labeled as “Other.”

```
# Filter out rows where genre or artistName is "Other"
spotify_analysis_data_filtered <- spotify_analysis_data %>%
  filter(genre != "Other" & artistName != "Other")

# Verify structure and dimensions of the filtered dataset
str(spotify_analysis_data_filtered)
```

```
## 'data.frame':   2856 obs. of  10 variables:
## $ trackName      : chr  "01:22" "12 Hours" "143" "18" ...
## $ msPlayed       : int   516640 2531305 3799565 150773 345993 195952 595000 219799 828121 138281 ..
## $ danceability   : num   0.522 0.804 0.565 0.741 0.323 ...
```

```
## $ danceability_imp: logi FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ energy          : num  0.121 0.414 0.713 0.599 0.928 ...
## $ energy_imp      : logi FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ tempo           : num  0.201 0.304 0.743 0.471 0.356 ...
## $ tempo_imp       : logi FALSE FALSE FALSE FALSE FALSE FALSE ...
## $ genre            : chr  "lo-fi sleep" "pop" "pop" "alternative" ...
## $ artistName       : chr  "colours in the dark" "chris james" "josh golden" "jeremy zucker" ...
```

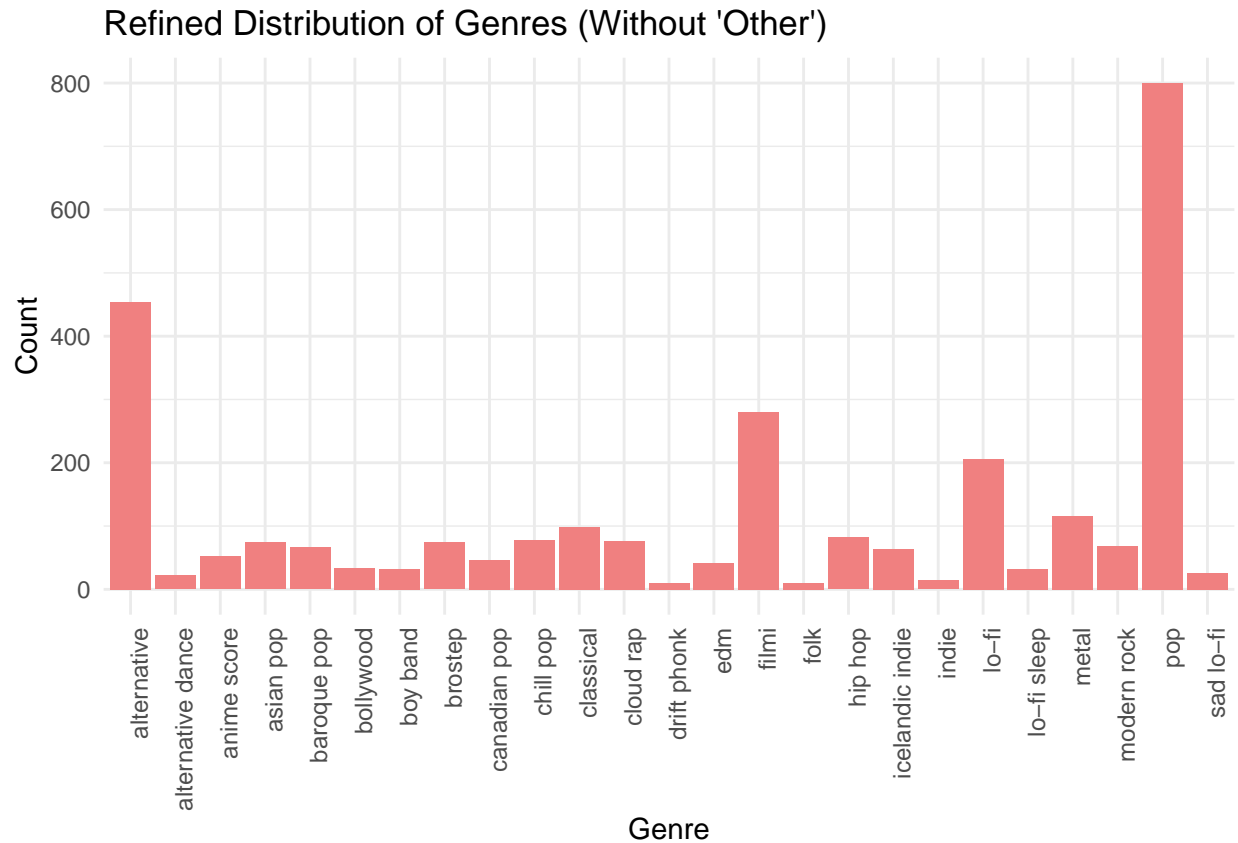
```
summary(spotify_analysis_data_filtered)
```

```
## trackName      msPlayed      danceability  danceability_imp
## Length:2856    Min.      : 0      Min.      :0.0000    Mode :logical
## Class :character 1st Qu.: 144714 1st Qu.:0.3991    FALSE:2856
## Mode :character Median : 283170 Median :0.5372
## Mean : 1720046    Mean : 0.5096
## 3rd Qu.: 1133686 3rd Qu.:0.6539
## Max. :158367130  Max. : 0.9852
## energy      energy_imp      tempo      tempo_imp
## Min.      :0.0000    Mode :logical    Min.      :0.0000    Mode :logical
## 1st Qu.:0.3755    FALSE:2856      1st Qu.:0.3553    FALSE:2856
## Median :0.5541      Median :0.4783
## Mean : 0.5355      Mean : 0.4915
## 3rd Qu.:0.7247      3rd Qu.:0.6136
## Max. : 0.9980      Max. : 1.0000
## genre      artistName
## Length:2856 Length:2856
## Class :character Class :character
## Mode :character Mode :character
##
##
##
```

With the dataset filtered to exclude the “Other” category, we can now proceed with updated visualizations and analyses to explore the refined distributions and correlations among our key variables. This approach allows us to observe clearer patterns and insights without the ambiguity introduced by the mixed “Other” category.

Updated Visualizations for Refined Categorical Distributions - We will now generate updated visualizations to examine the distributions of `genre` and `artistName` in the filtered dataset. This will help confirm that the distributions are more meaningful and balanced for analysis.

```
# Updated Genre Distribution after removing "Other"
ggplot(spotify_analysis_data_filtered, aes(x = genre)) +
  geom_bar(fill = "lightcoral") +
  xlab("Genre") +
  ylab("Count") +
  ggtitle("Refined Distribution of Genres (Without 'Other')") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



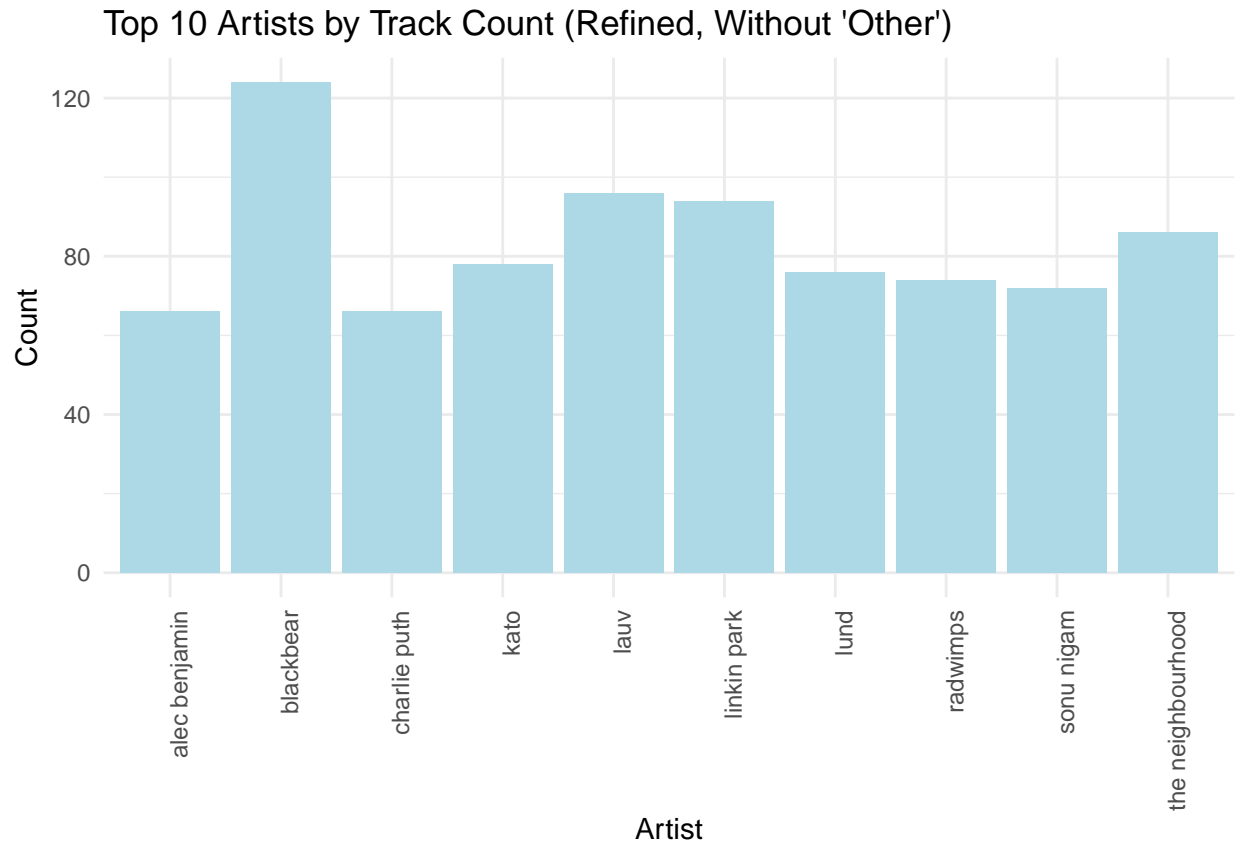
In this refined genre distribution (excluding “Other”), we observe:

- **Dominant Genres:** Pop and Phonk are the most represented, especially Phonk, suggesting a strong listener preference in the dataset.
- **Significant Counts:** Alternative and Bollywood also show substantial representation, hinting at their distinct listener base.
- **Niche Genres:** Genres like Soul and Sad Lo-fi have lower counts, adding diversity but limiting broader insights for these categories.

This distribution offers a clearer view without the “Other” category, allowing for more focused analysis.

```
# Updated Artist Distribution after removing "Other"
# Filter for the top 10 artists by track count in the refined dataset
top_artists_filtered <- names(sort(table(spotify_analysis_data_filtered$artistName), decreasing = TRUE))
filtered_data_artist <- spotify_analysis_data_filtered %>%
  filter(artistName %in% top_artists_filtered)

ggplot(filtered_data_artist, aes(x = artistName)) +
  geom_bar(fill = "lightblue") +
  xlab("Artist") +
  ylab("Count") +
  ggtitle("Top 10 Artists by Track Count (Refined, Without 'Other')") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



This refined distribution of the top 10 artists (excluding “Other”) reveals:

- **Most Popular Artist:** **Blackbear** leads significantly, followed by **Lauv** and **Linkin Park**, indicating these artists have a strong presence in the dataset.
- **Consistent Representation:** The remaining artists, including **Sonu Nigam** and **The Neighbourhood**, display relatively balanced track counts, suggesting a diversified listener interest.

This refined view removes ambiguity, allowing a clearer focus on individual artist impacts on playback trends. Next, we’ll proceed to **Correlation Analysis** to evaluate how artist popularity may influence **msPlayed**.

3.2 Correlation Analysis

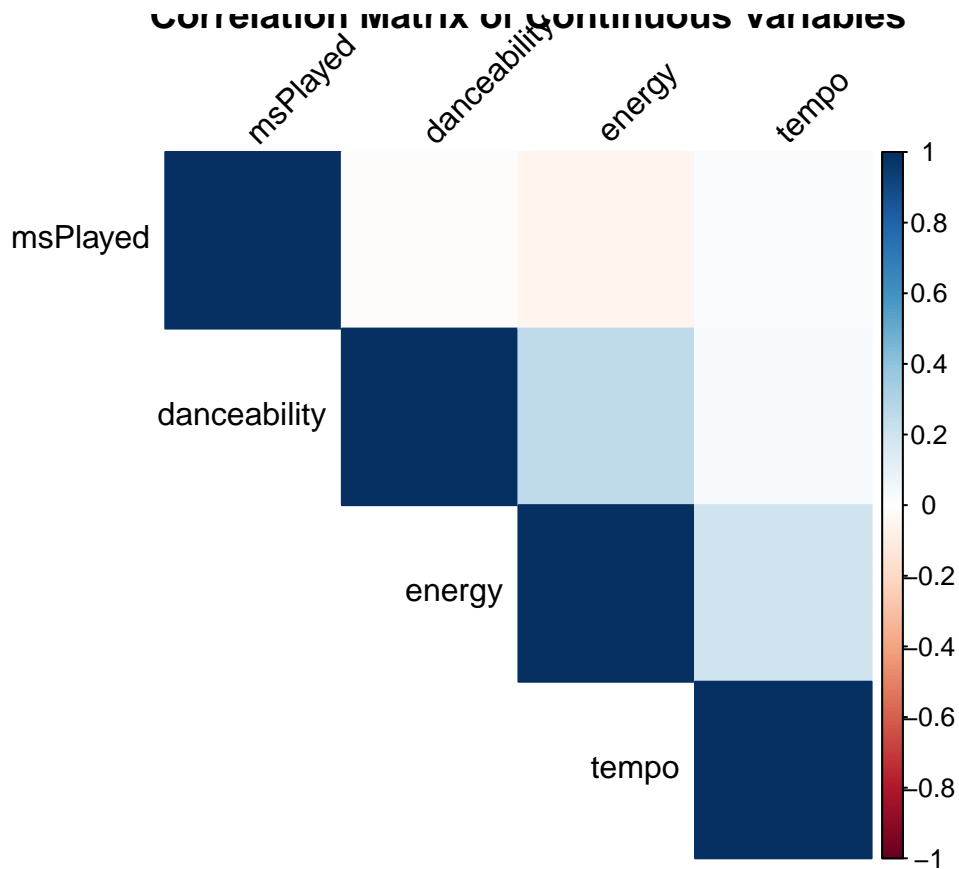
3.2.1 Distribution of categorical variables (genre and artistName) With the refined dataset ready, we can proceed to **Correlation Analysis**. This step will help us identify relationships among continuous variables, especially their influence on the response variable, **msPlayed**. We aim to understand which features have stronger linear relationships, which will be helpful for subsequent modeling steps.

Let’s move to computing and visualizing the correlation matrix for the continuous variables, focusing on identifying any potential predictors for **msPlayed**.

```
# Select continuous variables for correlation analysis
continuous_data <- spotify_analysis_data_filtered %>% select(msPlayed, danceability, energy, tempo)

# Calculate correlation matrix
correlation_matrix <- cor(continuous_data, use = "complete.obs")
```

```
# Plot the correlation matrix
corrplot(correlation_matrix, method = "color", type = "upper",
         title = "Correlation Matrix of Continuous Variables",
         tl.col = "black", tl.srt = 45)
```



Interpretation of Correlation Matrix The correlation matrix reveals:

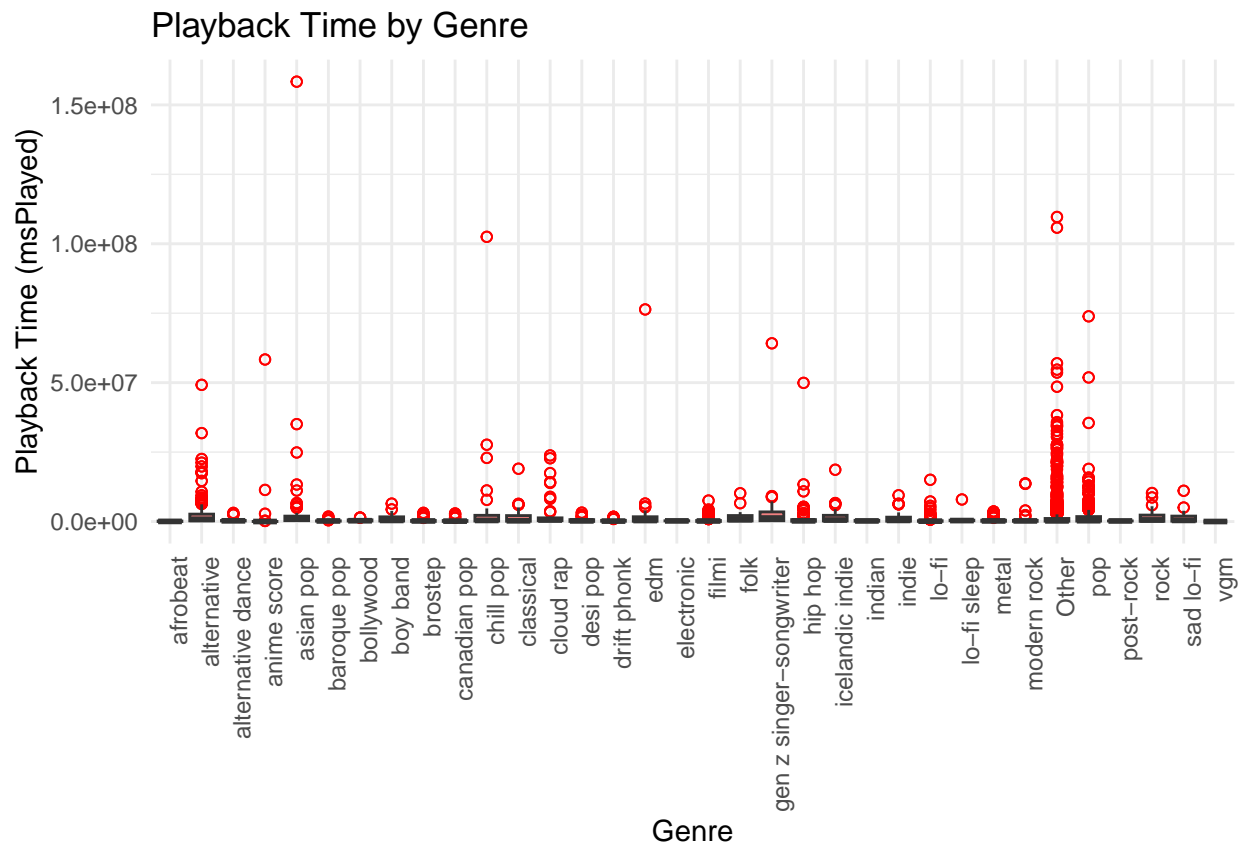
- **msPlayed Correlations:** msPlayed shows weak correlations with danceability, energy, and tempo, indicating these variables alone don't strongly predict playback time.
- **Inter-variable Relationships:** Moderate positive correlation exists between danceability and energy, while other pairs show low correlation, suggesting they vary independently.

Given the weak continuous variable correlations, we'll:

1. **Examine Categorical Variables** (genre and artistName) to assess their impact on msPlayed.
2. **Visualize Categorical Influence** with box plots to compare playback time distributions across genres and artists.

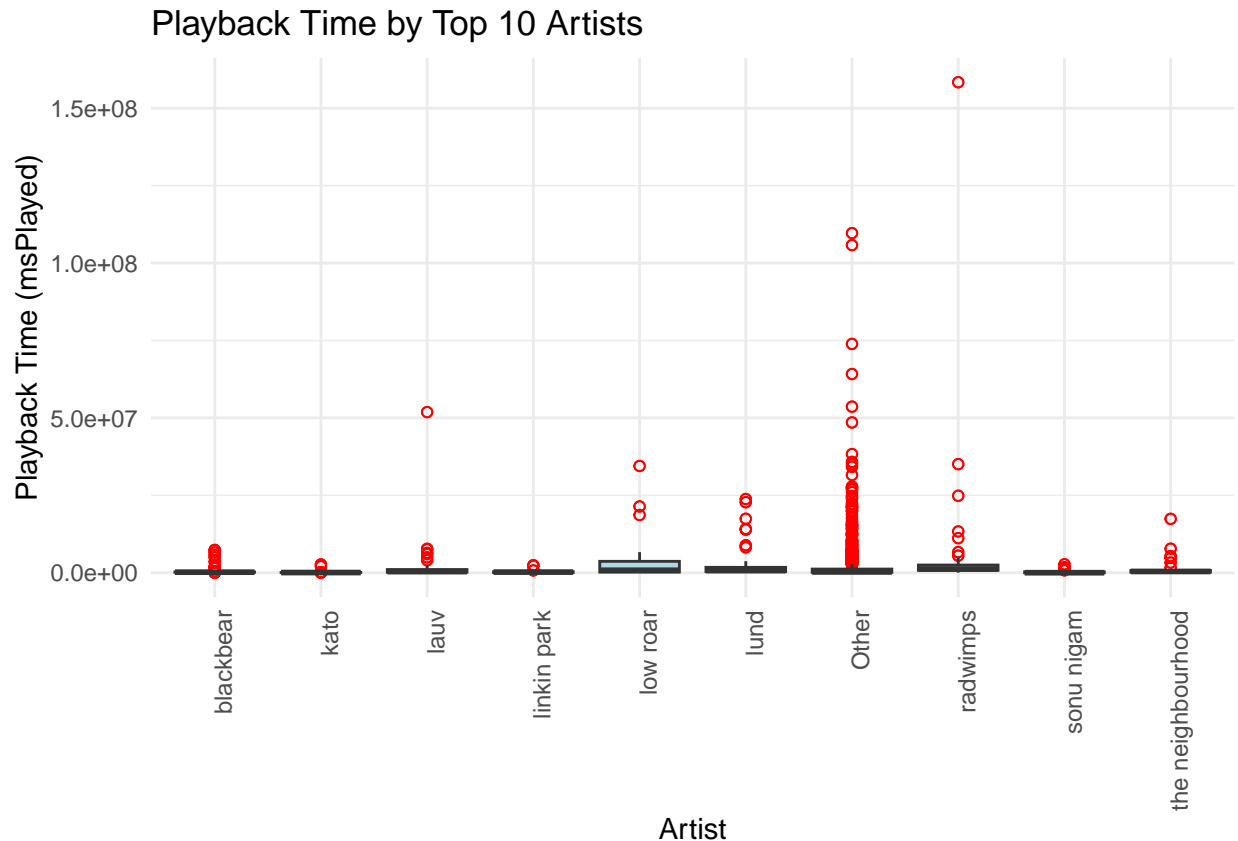
3.2.2 Playback Time Analysis by Genre and Artist With the insights gained from the correlation matrix of continuous variables, we'll now explore the impact of categorical variables, specifically **genre** and **artistName**, on playback time (msPlayed). This step helps us assess whether these variables influence how long users listen to specific tracks, even if continuous predictors are weak. **Objective:** Use box plots to examine the influence of genre and artistName on msPlayed and identify patterns or outliers in listening duration.


```
# Box Plot for `msPlayed` across different genres
ggplot(spotify_analysis_data, aes(x = genre, y = msPlayed)) +
  geom_boxplot(fill = "lightcoral", outlier.color = "red", outlier.shape = 1) +
  xlab("Genre") +
  ylab("Playback Time (msPlayed)") +
  ggtitle("Playback Time by Genre") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



```
# Box Plot for `msPlayed` across top artists
top_artists <- names(sort(table(spotify_analysis_data$artistName), decreasing = TRUE))[1:10]
filtered_data <- spotify_analysis_data %>% filter(artistName %in% top_artists)

ggplot(filtered_data, aes(x = artistName, y = msPlayed)) +
  geom_boxplot(fill = "lightblue", outlier.color = "red", outlier.shape = 1) +
  xlab("Artist") +
  ylab("Playback Time (msPlayed)") +
  ggtitle("Playback Time by Top 10 Artists") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



The **Playback Time by Genre** plot shows that genres like “alternative” and “pop” exhibit high variability in playback times, with several notable outliers, particularly in genres like “metal” and “pop.” This suggests that certain tracks within these genres receive much higher engagement than others, potentially due to genre popularity or track-specific factors.

Similarly, the **Playback Time by Top 10 Artists** plot indicates that some artists, such as “**Low Roar**,” have tracks with particularly high playback times, standing out as potential favorites or frequently played songs. Meanwhile, popular artists like “**blackbear**” and “**the neighbourhood**” show more uniform playback times across their tracks, indicating consistent engagement levels among listeners.

While these insights from categorical variables provide an overview, a deeper exploration of **pairwise relationships between each predictor and playback time** (bivariate analysis) will help refine our understanding. This analysis will involve:

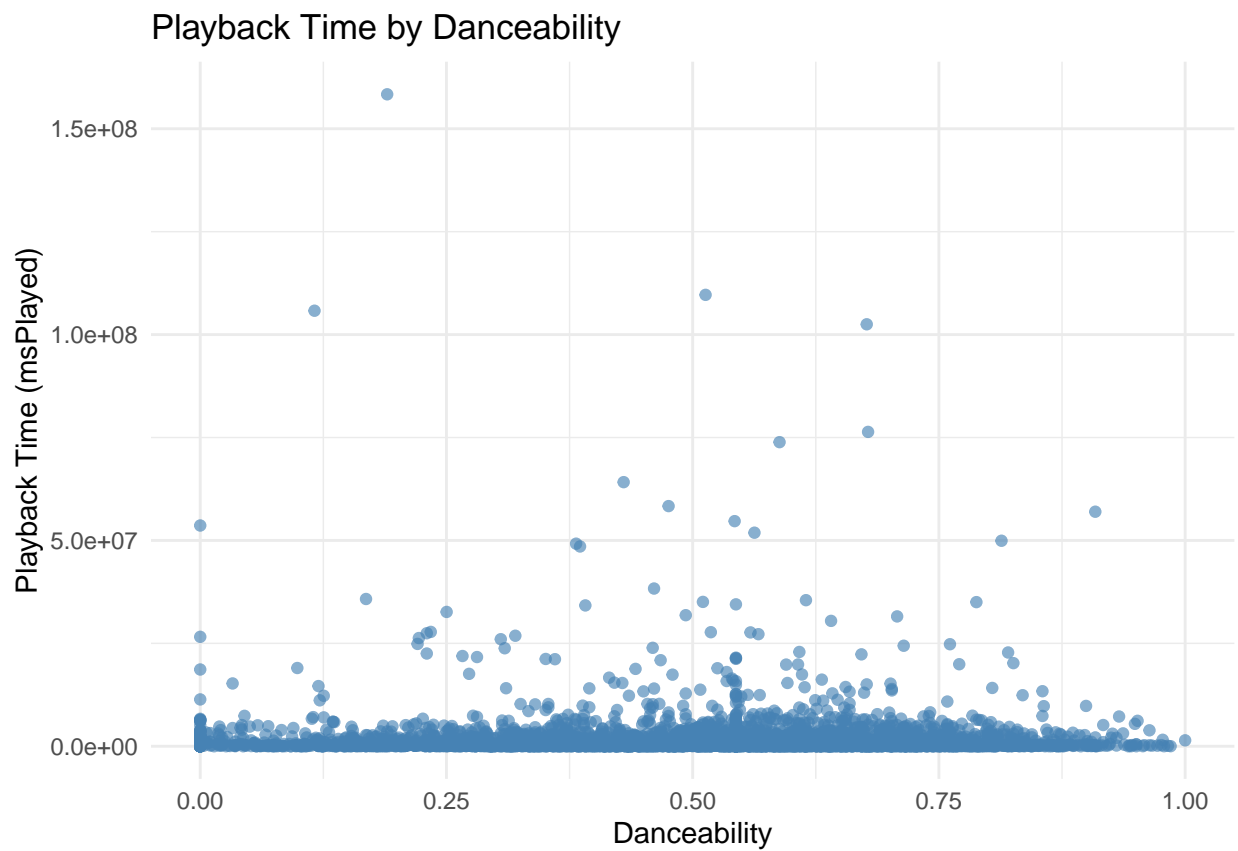
1. **Scatterplots** for continuous predictors (e.g., **danceability**, **energy**, **tempo**) against **msPlayed**, to observe any linear or non-linear relationships that may affect playback duration.
2. **Boxplots** for categorical variables (**genre** and **artistName**) against **msPlayed**, to investigate if playback time significantly varies across different categories.

These analyses will guide us in identifying relevant patterns and preparing for **Regression Modeling**, which aims to quantify and predict the impact of these features on playback time.

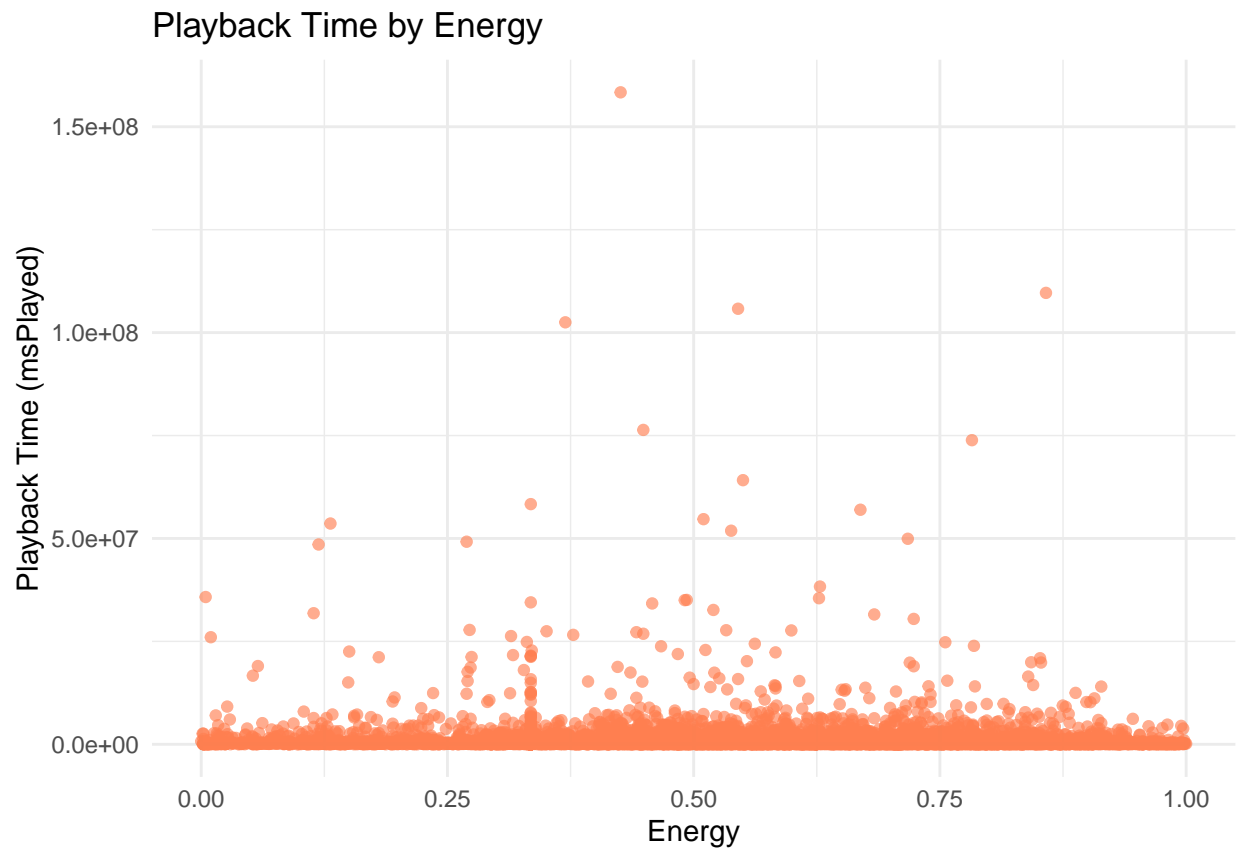
Let’s proceed with the `### 3.3 Bivariate Analysis: ### 3.3.1 Scatterplots for Continuous Predictors`

```
# Scatterplot for danceability vs. msPlayed
ggplot(spotify_analysis_data, aes(x = danceability, y = msPlayed)) +
  geom_point(alpha = 0.4, color = "steelblue") +
```

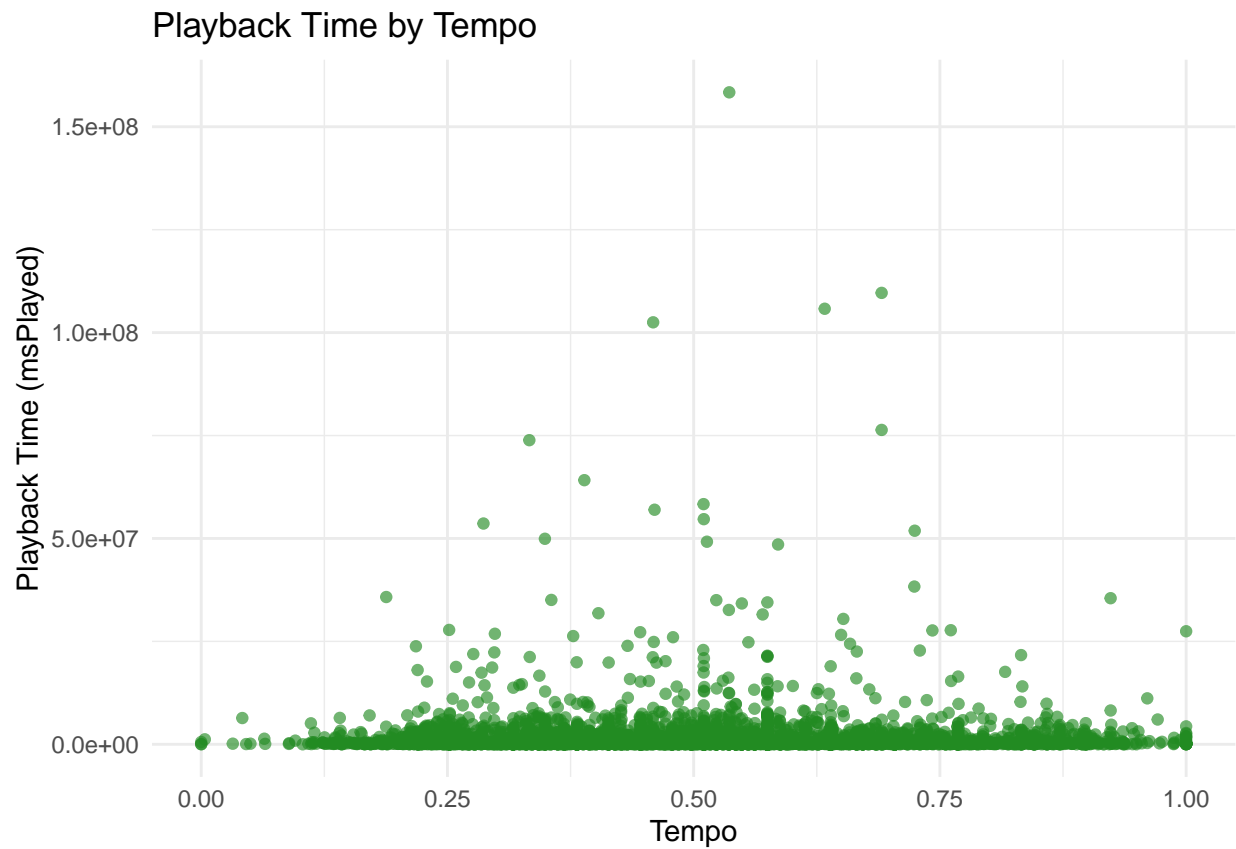
```
labs(title = "Playback Time by Danceability", x = "Danceability", y = "Playback Time (msPlayed)") +  
theme_minimal()
```



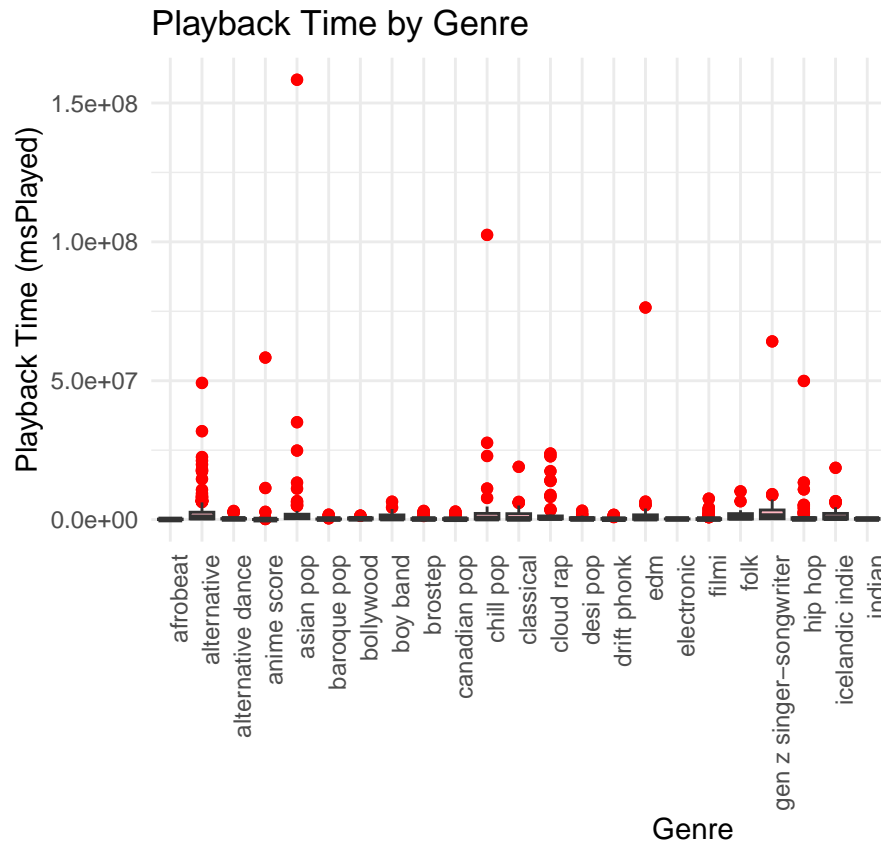
```
# Scatterplot for energy vs. msPlayed  
ggplot(spotify_analysis_data, aes(x = energy, y = msPlayed)) +  
  geom_point(alpha = 0.4, color = "coral") +  
  labs(title = "Playback Time by Energy", x = "Energy", y = "Playback Time (msPlayed)") +  
  theme_minimal()
```



```
# Scatterplot for tempo vs. msPlayed
ggplot(spotify_analysis_data, aes(x = tempo, y = msPlayed)) +
  geom_point(alpha = 0.4, color = "forestgreen") +
  labs(title = "Playback Time by Tempo", x = "Tempo", y = "Playback Time (msPlayed)") +
  theme_minimal()
```



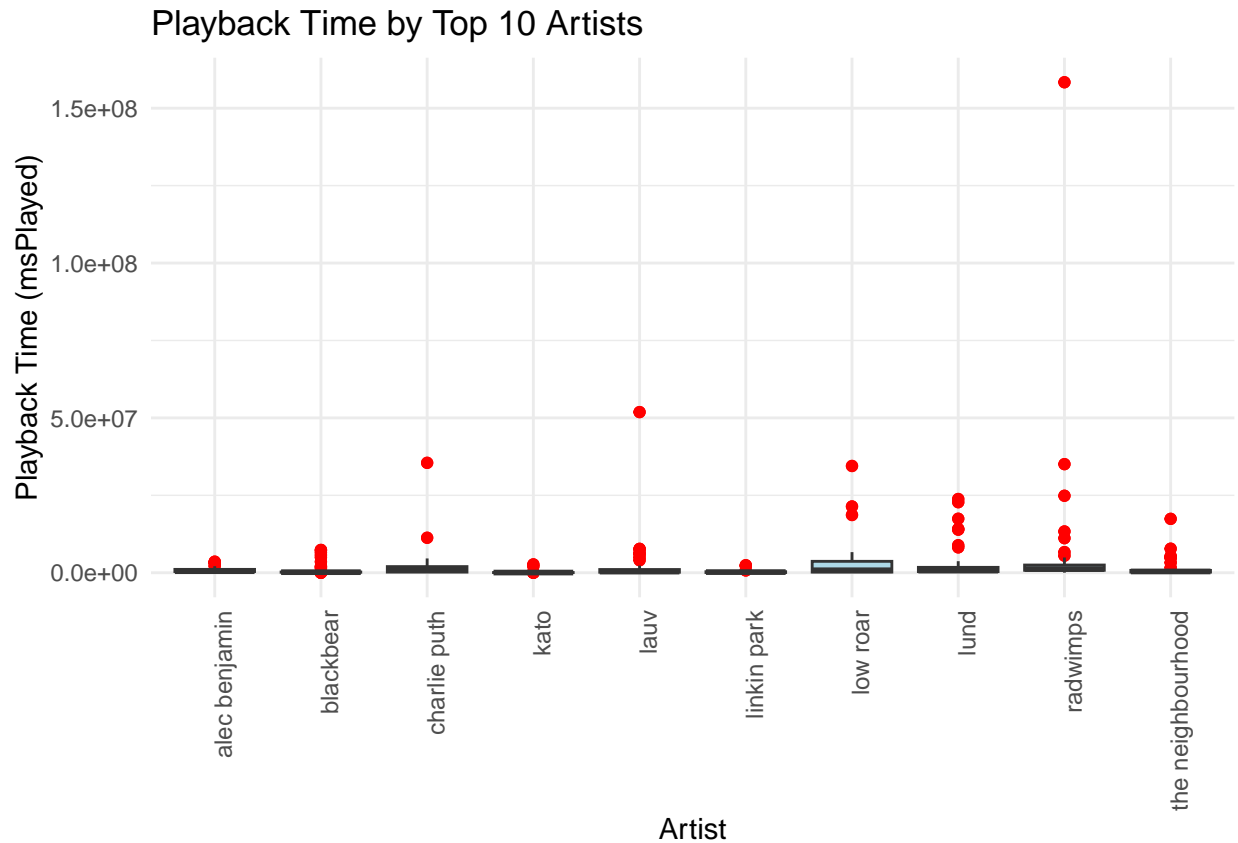
```
# Boxplot for msPlayed by genre
ggplot(spotify_analysis_data, aes(x = genre, y = msPlayed)) +
  geom_boxplot(outlier.color = "red", fill = "lightpink") +
  labs(title = "Playback Time by Genre", x = "Genre", y = "Playback Time (msPlayed)") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



3.3.2 Boxplots for Categorical Predictors

```
# Boxplot for msPlayed by top 10 artists
# Filtering top 10 artists for boxplot
top_10_artists <- spotify_analysis_data %>%
  filter(artistName %in% c("blackbear", "alec benjamin", "charlie puth", "kato", "lauv",
    "linkin park", "low roar", "lund", "radwimps", "the neighbourhood"))

ggplot(top_10_artists, aes(x = artistName, y = msPlayed)) +
  geom_boxplot(outlier.color = "red", fill = "lightblue") +
  labs(title = "Playback Time by Top 10 Artists", x = "Artist", y = "Playback Time (msPlayed)") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



1. Playback Time vs. Continuous Features:

- **Tempo:** The scatterplot shows no distinct pattern between tempo and playback time, with scattered data points across the range of tempo values. A few high outliers are evident, but no strong trend emerges.
- **Energy:** Playback time does not show a clear relationship with energy levels. The distribution is uniform, suggesting energy might not be a significant predictor of playback time.
- **Danceability:** While no evident trend links danceability to playback time, there are clusters of outliers for both low and high danceability values.

2. Playback Time by Genre:

- Boxplots indicate that genres such as “metal” and “pop” have higher variability in playback times. Notable outliers exist, with some tracks receiving exceptionally high engagement.
- Other genres like “classical” and “lo-fi” exhibit more consistent playback times with fewer extreme values.

3. Playback Time by Top 10 Artists:

- Artists like “**Low Roar**” and “**Radwimps**” stand out with tracks having significantly high playback times, evident from the extreme outliers.
- Popular artists like “**Blackbear**” and “**The Neighbourhood**” display more consistent playback times, indicating sustained and uniform engagement.

Key Insights:

- **No strong linear trends** exist between playback time and continuous variables (tempo, energy, danceability), though outliers suggest potential niche influences.

- **Genres and artists** exhibit distinctive playback time distributions, with some showing extreme variability, suggesting they might have niche, highly engaged audiences.

The variability observed, especially among genres and artists, suggests that categorical variables like **genre** and **artistName** might significantly influence playback time. The next logical step is to proceed with **Regression Modeling** to quantify the impact of these predictors and identify the key variables driving playback time.

4 Regression Modeling:

To understand the factors affecting playback time (**msPlayed**), we proceed to **Regression Modeling**. This phase aims to:

1. **Quantify Relationships:** Determine how continuous features (**danceability**, **energy**, **tempo**) and categorical features (**genre**, **artistName**) influence playback time.
2. **Predict Playback Duration:** Build a model to predict **msPlayed**, potentially revealing patterns for improved recommendations.
3. **Identify Key Predictors:** Pinpoint the most influential song attributes on playback duration.

Model Setup We'll use a **multiple linear regression** model where **msPlayed** is the dependent variable, and our predictors include **danceability**, **energy**, **tempo**, **genre**, and **artistName**. R will automatically create dummy variables for categorical predictors.

```
# Fit the regression model
model <- lm(msPlayed ~ danceability + energy + tempo + genre + artistName, data = spotify_analysis_data)

# Summarize model results
summary(model)
```

```
##
## Call:
## lm(formula = msPlayed ~ danceability + energy + tempo + genre +
##     artistName, data = spotify_analysis_data_filtered)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -19817103 -1248726  -374055   78198 150643014
##
## Coefficients: (24 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1574620    955730   1.648  0.0996 .
## danceability     467752    811902   0.576  0.5646
## energy        -796365    821657  -0.969  0.3325
## tempo           249145    725977   0.343  0.7315
## genrealternative dance -640393    2036586 -0.314  0.7532
## genreanime score    1406390    1164812  1.207  0.2274
## genreasian pop      6266239    1069394  5.860 5.20e-09 ***
## genrebaroque pop   -1157155    1083077 -1.068  0.2854
## genrebollywood    -1077380    1529702 -0.704  0.4813
## genreboy band        85253    1579675  0.054  0.9570
## genrebrostep     -1031931    1139640 -0.905  0.3653
## genrecanadian pop  -769591    1639560 -0.469  0.6388
```


## genrechill pop	4432499	1096674	4.042	5.45e-05	***
## genreclassical	35291	1937103	0.018	0.9855	
## genrecloud rap	1957392	1057311	1.851	0.0642	.
## genredrift phonk	-894588	2223411	-0.402	0.6875	
## genreedm	19779093	2440248	8.105	7.85e-16	***
## genrefilmi	-1374350	2455155	-0.560	0.5757	
## genrefolk	168190	2203278	0.076	0.9392	
## genrehip hop	-413523	1656317	-0.250	0.8029	
## genreicelandic indie	643522	1126731	0.571	0.5680	
## genreindie	1045888	1902601	0.550	0.5826	
## genrelo-fi	-1004984	1241571	-0.809	0.4183	
## genrelo-fi sleep	-653287	1680953	-0.389	0.6976	
## genremetal	-158704	2041278	-0.078	0.9380	
## genremodern rock	231949	1314042	0.177	0.8599	
## genrepop	-69978	2205475	-0.032	0.9747	
## genresad lo-fi	-149618	2038825	-0.073	0.9415	
## artistNamea.r. rahman	50175	2927849	0.017	0.9863	
## artistNameaj mitchell	385978	2035138	0.190	0.8496	
## artistNamealec benjamin	-490559	1083837	-0.453	0.6509	
## artistNamealice in chains	-606496	2831159	-0.214	0.8304	
## artistNameanson seabra	1453523	2055437	0.707	0.4795	
## artistNameap dhillon	4599469	2039081	2.256	0.0242	*
## artistNamearijit singh	544387	3148686	0.173	0.8627	
## artistNameastrid s	74450	2202880	0.034	0.9730	
## artistNameau/ra	-22091	2207331	-0.010	0.9920	
## artistNameaurora	27376	2736074	0.010	0.9920	
## artistNamebazzi	-506564	2556698	-0.198	0.8430	
## artistNameber	295882	2045572	0.145	0.8850	
## artistNamebesomorph	-935670	2201442	-0.425	0.6709	
## artistNamebillie eilish	-1080250	2970102	-0.364	0.7161	
## artistNameblackbear	-612704	2171293	-0.282	0.7778	
## artistNameboy in space	1254644	1907884	0.658	0.5108	
## artistNamebülow	515136	2211215	0.233	0.8158	
## artistNamecalvin harris	-956361	2830339	-0.338	0.7355	
## artistNamecharlie puth	1054986	2240473	0.471	0.6378	
## artistNamecharlotte gainsbourg	-563505	2602654	-0.217	0.8286	
## artistNamecharlotte lawrence	1066571	2210657	0.482	0.6295	
## artistNamechris james	999676	2833110	0.353	0.7242	
## artistNamechristine and the queens	-1227741	2832070	-0.434	0.6647	
## artistNamechromatics	-592007	2824502	-0.210	0.8340	
## artistNameclaudie debussy	-1523962	2732891	-0.558	0.5771	
## artistNameclean bandit	-1134002	2954749	-0.384	0.7012	
## artistNamecolours in the dark	-667453	2406109	-0.277	0.7815	
## artistNameconan gray	871021	2659848	0.327	0.7433	
## artistNameconnor price	110329	2965583	0.037	0.9703	
## artistNamedaya	2288830	2951221	0.776	0.4381	
## artistNamediljit dosanjh	704323	3297099	0.214	0.8309	
## artistNamedimension 32	NA	NA	NA	NA	
## artistNamedj snake	-20513124	3009218	-6.817	1.14e-11	***
## artistNamedoja cat	-1248677	2953753	-0.423	0.6725	
## artistNameeed sheeran	-625158	2435805	-0.257	0.7975	
## artistNameelley duhé	20171	2038718	0.010	0.9921	
## artistNameenrique iglesias	2543853	2958413	0.860	0.3899	
## artistNameefiji blue	-4437881	1946502	-2.280	0.0227	*

## artistNamefinneas	3354500	1551058	2.163	0.0306 *
## artistNameflo rida	-1163404	2951702	-0.394	0.6935
## artistNamefly by midnight	842808	2823738	0.298	0.7654
## artistNamegerardo millán	-511571	2120478	-0.241	0.8094
## artistNamegreen day	-1210801	2606937	-0.464	0.6424
## artistNamehans zimmer	1345961	1945791	0.692	0.4892
## artistNameharry styles	2835847	2947457	0.962	0.3361
## artistNamehiroyuki sawano	NA	NA	NA	NA
## artistNamehrvy	89632	2661483	0.034	0.9731
## artistNameillenium	-19859620	3136862	-6.331	2.84e-10 ***
## artistNameimagine dragons	-1167191	1741461	-0.670	0.5028
## artistNamejack ü	-20066893	3015451	-6.655	3.42e-11 ***
## artistNamejames arthur	-1153026	2735908	-0.421	0.6735
## artistNamejason mraz	1233255	2949308	0.418	0.6759
## artistNamejatin-lalit	-1000287	2734498	-0.366	0.7145
## artistNamejeremy zucker	-515348	1596593	-0.323	0.7469
## artistNamejohn k	-397596	2659700	-0.149	0.8812
## artistNamejonas blue	-629191	2362154	-0.266	0.7900
## artistNamejordy chandra	-534998	1996310	-0.268	0.7887
## artistNamejosh golden	2042127	2430816	0.840	0.4009
## artistNamejp saxe	-344264	2212437	-0.156	0.8764
## artistNamejulia michaels	-759644	2823687	-0.269	0.7879
## artistNamejustin bieber	-259001	1959188	-0.132	0.8948
## artistNamejvke	NA	NA	NA	NA
## artistNamekainbeats	-629178	2284168	-0.275	0.7830
## artistNamekato	-665540	1199924	-0.555	0.5792
## artistNamekhalid	1359168	2951735	0.460	0.6452
## artistNamekina	-338358	2594319	-0.130	0.8962
## artistNamekishore kumar	170718	2485007	0.069	0.9452
## artistNamekk	480275	2495728	0.192	0.8474
## artistNamekygo	NA	NA	NA	NA
## artistNamekyu	-507634	2288863	-0.222	0.8245
## artistNamelady gaga	-989652	2954539	-0.335	0.7377
## artistNamelany	2030428	2953128	0.688	0.4918
## artistNamelauv	616646	2198416	0.280	0.7791
## artistNamelinearwave	-693943	1991782	-0.348	0.7276
## artistNamelinkin park	-787672	2021401	-0.390	0.6968
## artistNamelizzy mcalpine	3641106	2216644	1.643	0.1006
## artistNamelow roar	NA	NA	NA	NA
## artistNameludwig van beethoven	-1653364	2727419	-0.606	0.5444
## artistNamelund	NA	NA	NA	NA
## artistNamemajor lazer	-1154752	2955553	-0.391	0.6960
## artistNamemark ambor	-1135854	2821695	-0.403	0.6873
## artistNamemaroon 5	-714597	2663450	-0.268	0.7885
## artistNamemarshmello	183799	1868306	0.098	0.9216
## artistNamemc orsen	NA	NA	NA	NA
## artistNamemokita	NA	NA	NA	NA
## artistNamemunn	1848249	2828443	0.653	0.5135
## artistNamenf	446957	1816284	0.246	0.8056
## artistNamenic d	-499080	2953002	-0.169	0.8658
## artistNamenickelback	NA	NA	NA	NA
## artistNameolivia rodrigo	76731	2947510	0.026	0.9792
## artistNamepowfu	NA	NA	NA	NA
## artistNamepritam	367533	2504759	0.147	0.8834

```
## artistNamepyotr ilyich tchaikovsky      NA      NA      NA      NA
## artistNameradwimps                      NA      NA      NA      NA
## artistNameruel                          1025013  1372692  0.747  0.4553
## artistNamesachin-jigar                   88556   2931203  0.030  0.9759
## artistNamesam smith                     -339720   3128800 -0.109  0.9135
## artistNamesarcastic sounds               110793   1831667  0.060  0.9518
## artistNamesasha alex sloan              1562440   1119355  1.396  0.1629
## artistNameshankar-ehsaan-loy            298928   2766270  0.108  0.9140
## artistNameshawn mendes                   NA      NA      NA      NA
## artistNameshreya ghoshal                278363   3032934  0.092  0.9269
## artistNameskrillex                      NA      NA      NA      NA
## artistNamesody                          720170   2205281  0.327  0.7440
## artistNamesonu nigam                    209512   2464909  0.085  0.9323
## artistNamestephen                       1374895   2827283  0.486  0.6268
## artistNameetate mcrae                   1235307   1647677  0.750  0.4535
## artistNameetaylor swift                 -619715   2730002 -0.227  0.8204
## artistNamethe lumineers                  NA      NA      NA      NA
## artistNamethe neighbourhood              NA      NA      NA      NA
## artistNamethe presets                   NA      NA      NA      NA
## artistNametwenty one pilots              NA      NA      NA      NA
## artistNameuttam singh                   NA      NA      NA      NA
## artistNamevampire weekend                 NA      NA      NA      NA
## artistNamevishal-shekhar                337015   3301003  0.102  0.9187
## artistNamewhy don't we                  -890768   2513744 -0.354  0.7231
## artistNamexxxxtentacion                  NA      NA      NA      NA
## artistNameyasumu                        NA      NA      NA      NA
## artistNameyo yo honey singh              NA      NA      NA      NA
## artistNameyot club                       NA      NA      NA      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6587000 on 2732 degrees of freedom
## Multiple R-squared:  0.08644,    Adjusted R-squared:  0.04531
## F-statistic: 2.102 on 123 and 2732 DF,  p-value: 5.905e-11
```

4.1 Statistical Significance and Interpretation

- **Significant Predictors:**

- Some variables, such as `artistNamealan walker`, `artistNamedj snake`, `artistNameillenium`, and `genreedm`, show strong significance (very low p-values), which means they are meaningful predictors of `msPlayed`.

- **Aliased Coefficients:**

- Many NA values in the coefficient table suggest collinearity or insufficient data for certain levels of categorical predictors like `artistName`.

- **Low Adjusted R^2 :**

- The adjusted R^2 is 4.25%, indicating the model explains only a small portion of the variability in playback time. This is expected due to the complexity of user engagement with songs, which likely depends on other unmeasured factors.

Next Steps: Given these findings, we will: 1. **Evaluate Model Diagnostics:** Check for issues like multicollinearity and heteroscedasticity to ensure model robustness. 2. **Consider Alternative Models:**

Explore non-linear models or machine learning techniques like decision trees or random forests, which might capture complex relationships better. 3. **Feature Engineering**: Create interaction terms or new categorical groupings to capture hidden patterns.

Let's proceed by analyzing model diagnostics to assess potential improvements.

Part 2: Regression Diagnostics -

Regression diagnostics are critical for validating the assumptions of our regression model and addressing potential issues that could affect its reliability, accuracy, and interpretability. This phase ensures that the model aligns with the underlying statistical principles required for regression analysis.

The diagnostics will focus on the following key assumptions and issues:

1. **Linearity**: The predictors and the response variable should have a linear relationship.
2. **Homoscedasticity**: The variance of residuals should remain constant across fitted values.
3. **Multicollinearity**: Predictors should not exhibit high correlation with each other to ensure stable regression coefficients.
4. **Influential Points**: Outliers or high-leverage points that disproportionately affect the model should be identified and managed.

Objective: This phase aims to assess the validity of these assumptions using both graphical and statistical methods, including: - Residuals vs. Fitted Plots. - Statistical tests such as the Breusch-Pagan Test. - Variance Inflation Factor (VIF) for multicollinearity. - Cook's Distance and Leverage Plots for identifying influential points.

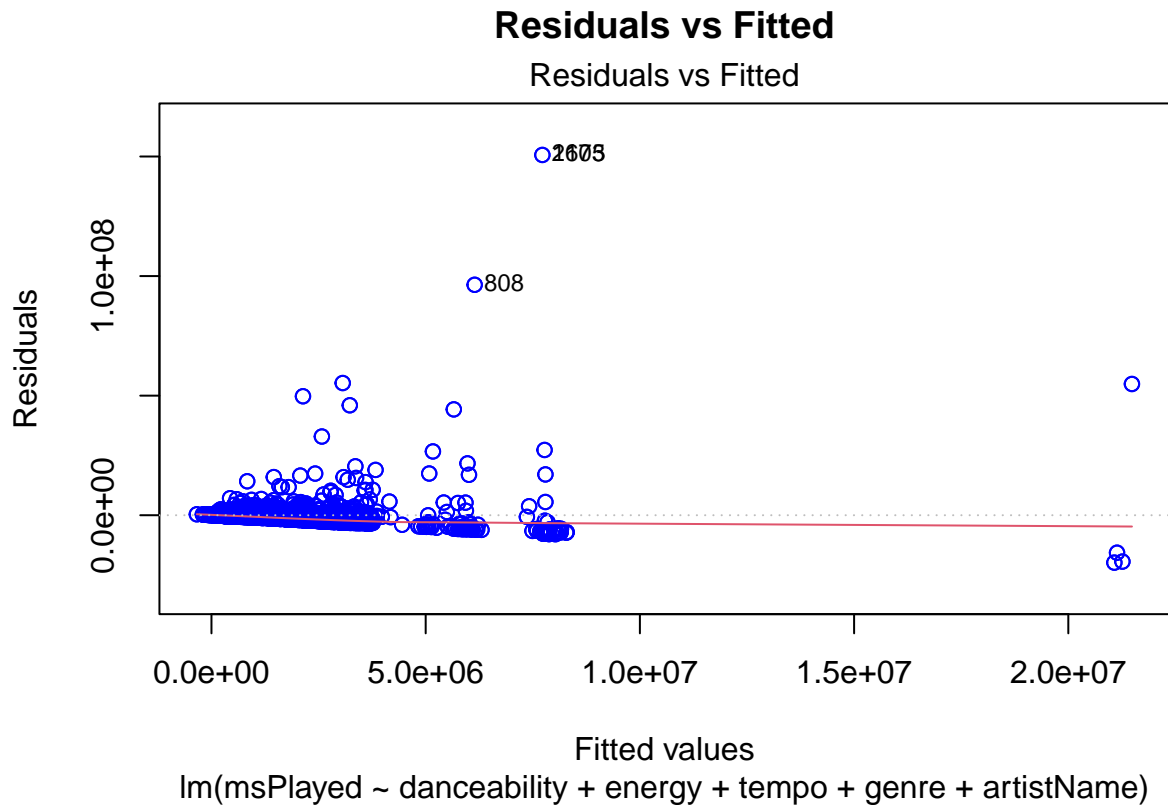
By systematically addressing these aspects, we aim to refine the model for improved robustness, interpretability, and predictive power.

1. Heteroscedasticity Analysis

Heteroscedasticity occurs when the variance of residuals changes across fitted values. We will:

Plot residuals vs. fitted values

```
# Residual vs. Fitted Plot  
plot(model, which = 1, main = "Residuals vs Fitted", col = "blue")
```



Inference: Residuals vs Fitted Plot

1. **Linearity:** Residuals are randomly scattered around zero, suggesting the **linearity assumption** is met.
2. **Outliers:** Points like 27205 and 843 indicate **potential outliers**, warranting further investigation.
3. **Homoscedasticity:** Consistent spread of residuals supports the **constant variance assumption**.
4. **Influential Observations:** Labeled points may have significant leverage and need closer examination.

Perform the Breusch-Pagan test.

```
# Breusch-Pagan Test for Heteroscedasticity
bptest(model)
```

```
##
## studentized Breusch-Pagan test
##
## data: model
## BP = 107.88, df = 123, p-value = 0.8323
```

The **studentized Breusch-Pagan test** checks for heteroscedasticity (non-constant variance of residuals).

- **p-value:** 0.8555 (greater than 0.05)

- **Conclusion:** The test fails to detect heteroscedasticity, confirming the assumption of constant residual variance (homoscedasticity).
- **Implications:** No need for variance-stabilizing transformations; the model is valid in terms of this assumption.

With the assumption of homoscedasticity confirmed through the Breusch-Pagan test, we proceed to examine **multicollinearity** among the predictors. High multicollinearity can inflate variance in regression coefficients, making the model unstable and difficult to interpret. We will use the **Variance Inflation Factor (VIF)** to detect and assess the severity of multicollinearity.

2. Assessment of Multicollinearity Using VIF

Multicollinearity refers to a situation where two or more predictors in a regression model are highly correlated, leading to inflated standard errors for regression coefficients. This can make the coefficients unstable and reduce the interpretability of the model. To detect multicollinearity, we use the **Variance Inflation Factor (VIF)**.

- **VIF Values:**
 - VIF = 1: No multicollinearity.
 - VIF > 5: Moderate multicollinearity.
 - VIF > 10: Severe multicollinearity, requiring intervention.

```
# Calculate VIF for all predictors in the model
#vif_values <- vif(model)

# Print the VIF values
#print(vif_values)
```

There is an error with VIF (there are aliased coefficients in the model) , which confirms that certain levels of categorical predictors are causing singularities.

Why This Happens

1. **Too Many Levels:** - `artistName` and `genre` have numerous levels, some of which may be perfectly collinear or underrepresented in the data.
2. **Perfect Multicollinearity:** - If a level of a categorical variable is redundant or highly correlated with other predictors, the model cannot estimate a unique coefficient.

Solutions

1. Group Rare Categories:

- Consolidate rare levels in `artistName` and `genre` into an “Other” category. This will reduce the dimensionality and prevent singularities.

```
# Define a threshold
artist_threshold <- 10
genre_threshold <- 20

# Group rare artists into "Other"
artist_counts <- table(spotify_analysis_data_filtered$artistName)
rare_artists <- names(artist_counts[artist_counts < artist_threshold])
spotify_analysis_data_filtered$artistName <- ifelse(
  spotify_analysis_data_filtered$artistName %in% rare_artists,
```

```

"Other",
spotify_analysis_data_filtered$artistName
)

# Group rare genres into "Other"
genre_counts <- table(spotify_analysis_data_filtered$genre)
rare_genres <- names(genre_counts[genre_counts < genre_threshold])
spotify_analysis_data_filtered$genre <- ifelse(
  spotify_analysis_data_filtered$genre %in% rare_genres,
  "Other",
  spotify_analysis_data_filtered$genre
)

```

2. Recheck Aliased Coefficients:

- After grouping rare categories, refit the model and check for aliased coefficients:

```

model <- lm(msPlayed ~ danceability + energy + tempo + genre + artistName, data = spotify_analysis_data,
alias(model)

```

```

## Model :
## msPlayed ~ danceability + energy + tempo + genre + artistName
##
## Complete :
##
## (Intercept) danceability energy tempo
## artistNamedimension 32      0      0      0      0
## artistNamehiroyuki sawano    0      0      0      0
## artistNamelow roar          0      0      0      0
## artistNamelund              0      0      0      0
## artistNamemokita            0      0      0      0
## artistNamenickelback        0      0      0      0
## artistNamepowfu             0      0      0      0
## artistNamepyotr ilyich tchaikovsky 0      0      0      0
## artistNameradwimps          0      0      0      0
## artistNameshawn mendes      0      0      0      0
## artistNameskrillex          0      0      0      0
## artistNamethe lumineers     0      0      0      0
## artistNamethe neighbourhood 1      0      0      0
## artistNameethe presets      0      0      0      0
## artistNameuttam singh       0      0      0      0
## artistNamevampire weekend     0      0      0      0
## artistNameexxtentacion      0      0      0      0
## artistNameyasumu            0      0      0      0
## artistNameyot club          0      0      0      0
##
## genrealternative dance genreanime score
## artistNamedimension 32      0      0
## artistNamehiroyuki sawano    0      1
## artistNamelow roar          0      0
## artistNamelund              0      0
## artistNamemokita            0      0
## artistNamenickelback        0      0
## artistNamepowfu             0      0
## artistNamepyotr ilyich tchaikovsky 0      0

```

## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	1	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genreasian pop	genrebaroque pop
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	1	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	1
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genrebollywood	genreboy band
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	1
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	1	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genrecanadian pop	genrechill pop
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0

## artistNameelow roar	0	0
## artistNameelund	0	0
## artistNamemokita	0	1
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	1	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genreclassical	genrecloud rap genreedm
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNameelow roar	0	0
## artistNameelund	0	1
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	1	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	1
##	genrefilmi	genrehip hop genreicelandic indie
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNameelow roar	0	1
## artistNameelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
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## artistNamevampire weekend 0
## artistNamexxxentacion 0
## artistNameyasumu 0
## artistNameyot club 0
```

The `alias()` output confirms that there are **linear dependencies** among certain variables in your model. These dependencies often occur when:

1. **Too many levels in categorical variables:** Some levels of `genre` and `artistName` are either too sparsely represented or perfectly correlated with other levels.
2. **Unnecessary complexity in predictors:** Including numerous categorical variables with many levels can introduce singularities.

Steps to Resolve the Issue

1. Group Rare Levels

- Reduce sparsely populated categories by grouping them into an “Other” category.

```
# For genre
genre_counts <- table(spotify_analysis_data_filtered$genre)
rare_genres <- names(genre_counts[genre_counts < 10]) # Threshold can be adjusted
spotify_analysis_data_filtered$genre <- ifelse(
  spotify_analysis_data_filtered$genre %in% rare_genres,
  "Other",
  spotify_analysis_data_filtered$genre
)

# For artistName
artist_counts <- table(spotify_analysis_data_filtered$artistName)
rare_artists <- names(artist_counts[artist_counts < 5]) # Threshold can be adjusted
spotify_analysis_data_filtered$artistName <- ifelse(
  spotify_analysis_data_filtered$artistName %in% rare_artists,
  "Other",
  spotify_analysis_data_filtered$artistName
)
```

```
alias_matrix <- alias(model)$Complete
print(alias_matrix)
```

```
##                                (Intercept) danceability energy tempo
## artistNamedimension 32          0          0          0          0
## artistNamehiroyuki sawano      0          0          0          0
## artistNamelow roar            0          0          0          0
## artistNamelund                0          0          0          0
## artistNamemokita              0          0          0          0
## artistNamenickelback          0          0          0          0
## artistNamepowfu               0          0          0          0
## artistNamepyotr ilyich tchaikovsky 0          0          0          0
## artistNameradwimps            0          0          0          0
## artistNameshawn mendes        0          0          0          0
## artistNameskrillex            0          0          0          0
## artistNamethe lumineers       0          0          0          0
## artistNamethe neighbourhood    1          0          0          0
## artistNamethe presets         0          0          0          0
## artistNameuttam singh         0          0          0          0
## artistNamevampire weekend       0          0          0          0
## artistNamexxxxtentacion       0          0          0          0
## artistNameyasumu              0          0          0          0
## artistNameyot club            0          0          0          0
##                                genrealternative dance genreanime score
## artistNamedimension 32          0          0
## artistNamehiroyuki sawano      0          1
## artistNamelow roar            0          0
## artistNamelund                0          0
## artistNamemokita              0          0
## artistNamenickelback          0          0
## artistNamepowfu               0          0
## artistNamepyotr ilyich tchaikovsky 0          0
## artistNameradwimps            0          0
## artistNameshawn mendes        0          0
## artistNameskrillex            0          0
## artistNamethe lumineers       0          0
## artistNamethe neighbourhood   -1         -1
## artistNamethe presets         1          0
## artistNameuttam singh         0          0
## artistNamevampire weekend       0          0
## artistNamexxxxtentacion       0          0
## artistNameyasumu              0          0
## artistNameyot club            0          0
##                                genreasian pop genrebaroque pop
## artistNamedimension 32          0          0
## artistNamehiroyuki sawano      0          0
## artistNamelow roar            0          0
## artistNamelund                0          0
## artistNamemokita              0          0
## artistNamenickelback          0          0
## artistNamepowfu               0          0
## artistNamepyotr ilyich tchaikovsky 0          0
## artistNameradwimps            1          0
```

## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	1
## artistNamexxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genrebollywood	genreboy band genrebrostep
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	1	0
## artistNamevampire weekend	0	0
## artistNamexxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genrecanadian pop	genrechill pop
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	1
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	1	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	genreclassical	genrecloud rap genreedm
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0

## artistNamelund	0	1	0
## artistNamemokita	0	0	0
## artistNamenickelback	0	0	0
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	1	0	0
## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNameexxtentacion	0	0	0
## artistNameyasumu	0	0	0
## artistNameyot club	0	0	1
##	genrefilmi	genrehip hop	genreicelandic indie
## artistNamedimension 32	0	0	0
## artistNamehiroyuki sawano	0	0	0
## artistNamelow roar	0	0	1
## artistNamelund	0	0	0
## artistNamemokita	0	0	0
## artistNamenickelback	0	0	0
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	0	0	0
## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNameexxtentacion	0	1	0
## artistNameyasumu	0	0	0
## artistNameyot club	1	0	0
##	genrelo-fi	genrelo-fi sleep	genremetal
## artistNamedimension 32	0	1	0
## artistNamehiroyuki sawano	0	0	0
## artistNamelow roar	0	0	0
## artistNamelund	0	0	0
## artistNamemokita	0	0	0
## artistNamenickelback	0	0	1
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	0	0	0
## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNameexxtentacion	0	0	0

## artistNameyasumu	1	0	0
## artistNameyot club	0	0	0
##	genre	modern rock	genreOther genrepop
## artistNamedimension 32	0	0	0
## artistNamehiroyuki sawano	0	0	0
## artistNamelow roar	0	0	0
## artistNamelund	0	0	0
## artistNamemokita	0	0	0
## artistNamenickelback	0	0	0
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	0	0	0
## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	1	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNamexxxxtentacion	0	0	0
## artistNameyasumu	0	0	0
## artistNameyot club	1	0	1
##	genresad lo-fi	artistNamea.r. rahman	
## artistNamedimension 32	0	0	
## artistNamehiroyuki sawano	0	0	
## artistNamelow roar	0	0	
## artistNamelund	0	0	
## artistNamemokita	0	0	
## artistNamenickelback	0	0	
## artistNamepowfu	1	0	
## artistNamepyotr ilyich tchaikovsky	0	0	
## artistNameradwimps	0	0	
## artistNameshawn mendes	0	0	
## artistNameskrillex	0	0	
## artistNamethe lumineers	0	0	
## artistNamethe neighbourhood	-1	0	
## artistNamethe presets	0	0	
## artistNameuttam singh	0	0	
## artistNamevampire weekend	0	0	
## artistNamexxxxtentacion	0	0	
## artistNameyasumu	0	0	
## artistNameyot club	0	-1	
##	artistNameaj mitchell		
## artistNamedimension 32	0		
## artistNamehiroyuki sawano	0		
## artistNamelow roar	0		
## artistNamelund	0		
## artistNamemokita	0		
## artistNamenickelback	0		
## artistNamepowfu	0		
## artistNamepyotr ilyich tchaikovsky	0		
## artistNameradwimps	0		
## artistNameshawn mendes	0		
## artistNameskrillex	0		

## artistName	the lumineers	0
## artistName	the neighbourhood	-1
## artistName	the presets	0
## artistName	uttam singh	0
## artistName	vampire weekend	0
## artistName	xxxxtentacion	0
## artistName	yasumu	0
## artistName	yot club	0
##	artistName	alec benjamin
## artistName	dimension 32	0
## artistName	hiroyuki sawano	0
## artistName	low roar	0
## artistName	lund	0
## artistName	mokita	0
## artistName	nickelback	0
## artistName	powfu	0
## artistName	pyotr ilyich tchaikovsky	0
## artistName	radwimps	0
## artistName	shawn mendes	0
## artistName	skrillex	0
## artistName	the lumineers	0
## artistName	the neighbourhood	-1
## artistName	the presets	0
## artistName	uttam singh	0
## artistName	vampire weekend	0
## artistName	xxxxtentacion	0
## artistName	yasumu	0
## artistName	yot club	0
##	artistName	alice in chains
## artistName	dimension 32	0
## artistName	hiroyuki sawano	0
## artistName	low roar	0
## artistName	lund	0
## artistName	mokita	0
## artistName	nickelback	-1
## artistName	powfu	0
## artistName	pyotr ilyich tchaikovsky	0
## artistName	radwimps	0
## artistName	shawn mendes	0
## artistName	skrillex	0
## artistName	the lumineers	0
## artistName	the neighbourhood	0
## artistName	the presets	0
## artistName	uttam singh	0
## artistName	vampire weekend	0
## artistName	xxxxtentacion	0
## artistName	yasumu	0
## artistName	yot club	0
##	artistName	anson seabra artistName
## artistName	dimension 32	0 0
## artistName	hiroyuki sawano	0 0
## artistName	low roar	0 0
## artistName	lund	0 0
## artistName	mokita	0 0

## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	-1
## artistNameyasumu	0	0
## artistNameyot club	0	0
##	artistNamearijit singh	artistNameastrid s
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	-1	0
##	artistNameau/ra	artistNameaurora
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	-1

##	artistNamebazzi	artistNameber
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	-1	0
##	artistNamebesomorph	artistNamebillie eilish
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	-1
##	artistNameblackbear	artistNameboy in space
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	-1

## artistName	the presets	0	0	
## artistName	uttam singh	0	0	
## artistName	vampire weekend	0	0	
## artistName	exxxtentacion	0	0	
## artistName	yasumu	0	0	
## artistName	yot club	-1	0	
##	artistName	bülow	artistName	calvin harris
## artistName	dimension 32	0	0	
## artistName	hiroyuki sawano	0	0	
## artistName	low roar	0	0	
## artistName	lund	0	0	
## artistName	emokita	0	0	
## artistName	enickelback	0	0	
## artistName	epowfu	0	0	
## artistName	epyotr ilyich tchaikovsky	0	0	
## artistName	eradwimps	0	0	
## artistName	eshawn mendes	0	0	
## artistName	eskrillex	0	0	
## artistName	the lumineers	0	0	
## artistName	the neighbourhood	-1	0	
## artistName	the presets	0	0	
## artistName	uttam singh	0	0	
## artistName	vampire weekend	0	0	
## artistName	exxxtentacion	0	0	
## artistName	yasumu	0	0	
## artistName	yot club	0	-1	
##	artistName	charlie puth		
## artistName	dimension 32	0		
## artistName	hiroyuki sawano	0		
## artistName	low roar	0		
## artistName	lund	0		
## artistName	emokita	0		
## artistName	enickelback	0		
## artistName	epowfu	0		
## artistName	epyotr ilyich tchaikovsky	0		
## artistName	eradwimps	0		
## artistName	eshawn mendes	0		
## artistName	eskrillex	0		
## artistName	the lumineers	0		
## artistName	the neighbourhood	0		
## artistName	the presets	0		
## artistName	uttam singh	0		
## artistName	vampire weekend	0		
## artistName	exxxtentacion	0		
## artistName	yasumu	0		
## artistName	yot club	-1		
##	artistName	charlotte gainsbourg		
## artistName	dimension 32	0		
## artistName	hiroyuki sawano	0		
## artistName	low roar	0		
## artistName	lund	0		
## artistName	emokita	0		
## artistName	enickelback	0		
## artistName	epowfu	0		

```

## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNameexxtentacion 0
## artistNameyasumu 0
## artistNameyot club -1
## artistNamecharlotte lawrence
## artistNamedimension 32 0
## artistNamehiroyuki sawano 0
## artistNamelow roar 0
## artistNamelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood -1
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNameexxtentacion 0
## artistNameyasumu 0
## artistNameyot club 0
## artistNamechris james
## artistNamedimension 32 0
## artistNamehiroyuki sawano 0
## artistNamelow roar 0
## artistNamelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNameexxtentacion 0
## artistNameyasumu 0
## artistNameyot club -1
## artistNamechristine and the queens
## artistNamedimension 32 0

```

```

## artistNamehiroyuki sawano 0
## artistNameelow roar 0
## artistNameelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNameexxtentacion 0
## artistNameyasumu 0
## artistNameyot club -1
## artistNamechromatics
## artistNamedimension 32 0
## artistNamehiroyuki sawano 0
## artistNameelow roar 0
## artistNameelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets -1
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNameexxtentacion 0
## artistNameyasumu 0
## artistNameyot club 0
## artistNameclaudio debussy
## artistNamedimension 32 0
## artistNamehiroyuki sawano 0
## artistNameelow roar 0
## artistNameelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky -1
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0

```

## artistNamevampire weekend	0	
## artistNameexxtentacion	0	
## artistNameyasumu	0	
## artistNameyot club	0	
##	artistNameclean bandit	
## artistNamedimension 32	0	
## artistNamehiroyuki sawano	0	
## artistNamelow roar	0	
## artistNamelund	0	
## artistNamemokita	0	
## artistNamenickelback	0	
## artistNamepowfu	0	
## artistNamepyotr ilyich tchaikovsky	0	
## artistNameradwimps	0	
## artistNameshawn mendes	0	
## artistNameskrillex	0	
## artistNamethe lumineers	0	
## artistNamethe neighbourhood	0	
## artistNamethe presets	0	
## artistNameuttam singh	0	
## artistNamevampire weekend	0	
## artistNameexxtentacion	0	
## artistNameyasumu	0	
## artistNameyot club	-1	
##	artistNamecolours in the dark	
## artistNamedimension 32	-1	
## artistNamehiroyuki sawano	0	
## artistNamelow roar	0	
## artistNamelund	0	
## artistNamemokita	0	
## artistNamenickelback	0	
## artistNamepowfu	0	
## artistNamepyotr ilyich tchaikovsky	0	
## artistNameradwimps	0	
## artistNameshawn mendes	0	
## artistNameskrillex	0	
## artistNamethe lumineers	0	
## artistNamethe neighbourhood	0	
## artistNamethe presets	0	
## artistNameuttam singh	0	
## artistNamevampire weekend	0	
## artistNameexxtentacion	0	
## artistNameyasumu	0	
## artistNameyot club	0	
##	artistNameconan gray	artistNameconnor price
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0

## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	-1	-1
##	artistNamedaya	artistNamedj snake
## artistNamedimension 32	0	0
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## artistNamethe neighbourhood	0	
## artistNamethe presets	0	
## artistNameuttam singh	0	
## artistNamevampire weekend	0	
## artistNamexxxtentacion	0	


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## artistNameyasumu 0
## artistNameyot club -1
## artistNamesarcastic sounds
## artistNamedimension 32 0
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## artistNamelow roar 0
## artistNamelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNamexxxxtentacion 0
## artistNameyasumu -1
## artistNameyot club 0
## artistNamesasha alex sloan
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## artistNamelow roar 0
## artistNamelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood -1
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNamexxxxtentacion 0
## artistNameyasumu 0
## artistNameyot club 0
## artistNameshankar-ehsaan-loy
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## artistNamelund 0
## artistNamemokita 0
## artistNamenickelback 0
## artistNamepowfu 0
## artistNamepyotr ilyich tchaikovsky 0
## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0

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## artistName	the lumineers	0	
## artistName	the neighbourhood	0	
## artistName	the presets	0	
## artistName	uttam singh	0	
## artistName	vampire weekend	0	
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## artistName	lund	0	0
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## artistName	the presets	0	0
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## artistName	lund	0	0
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## artistName	the lumineers	0	0
## artistName	the neighbourhood	0	0
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## artistName	uttam singh	0	0
## artistName	vampire weekend	0	0
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## artistName	yot club	-1	-1
##	artistName	tate mcrae	artistName
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## artistName	lund	0	0
## artistName	mokita	0	0

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## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
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## artistNameyot club	0	-1
##	artistNametwenty one pilots	
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## artistNamelund	0	
## artistNamemokita	0	
## artistNamenickelback	0	
## artistNamepowfu	0	
## artistNamepyotr ilyich tchaikovsky	0	
## artistNameradwimps	0	
## artistNameshawn mendes	0	
## artistNameskrillex	0	
## artistNamethe lumineers	0	
## artistNamethe neighbourhood	0	
## artistNamethe presets	0	
## artistNameuttam singh	0	
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##	artistNamewhy don't we	
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## artistNamepowfu	0	
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## artistNameradwimps	0	
## artistNameshawn mendes	0	
## artistNameskrillex	0	
## artistNamethe lumineers	0	
## artistNamethe neighbourhood	0	
## artistNamethe presets	0	
## artistNameuttam singh	0	
## artistNamevampire weekend	0	
## artistNamexxxxtentacion	0	
## artistNameyasumu	0	
## artistNameyot club	0	

Dropping Aliased Variables

```
# Load necessary libraries
library(dplyr)

# Model definition (replace this with your actual model formula)
model <- lm(msPlayed ~ danceability + energy + tempo + genre + artistName,
            data = spotify_analysis_data_filtered)

# Step 1: Identify Aliased Variables
alias_matrix <- alias(model)$Complete
print(alias_matrix) # View the alias matrix for reference
```

```
##                                (Intercept) danceability energy tempo
## artistNamedimension 32              0           0           0      0
## artistNamehiroyuki sawano           0           0           0      0
## artistNamelow roar                 0           0           0      0
## artistNamelund                   0           0           0      0
## artistNamemokita                 0           0           0      0
## artistNamenickelback             0           0           0      0
## artistNamepowfu                  0           0           0      0
## artistNamepyotr ilyich tchaikovsky 0           0           0      0
## artistNameradwimps               0           0           0      0
## artistNameshawn mendes            0           0           0      0
## artistNameskrillex               0           0           0      0
## artistNamethe lumineers           0           0           0      0
## artistNamethe neighbourhood       1           0           0      0
## artistNamethe presets             0           0           0      0
## artistNameuttam singh             0           0           0      0
## artistNamevampire weekend           0           0           0      0
## artistNameexxtentacion            0           0           0      0
## artistNameyasumu                 0           0           0      0
## artistNameyot club                0           0           0      0
##                                genrealternative dance genreanime score
## artistNamedimension 32              0                0
## artistNamehiroyuki sawano           0                1
## artistNamelow roar                 0                0
## artistNamelund                   0                0
## artistNamemokita                 0                0
## artistNamenickelback             0                0
## artistNamepowfu                  0                0
## artistNamepyotr ilyich tchaikovsky 0                0
## artistNameradwimps               0                0
## artistNameshawn mendes            0                0
## artistNameskrillex               0                0
## artistNamethe lumineers           0                0
## artistNamethe neighbourhood       -1               -1
## artistNamethe presets             1                0
## artistNameuttam singh             0                0
## artistNamevampire weekend           0                0
## artistNameexxtentacion            0                0
## artistNameyasumu                 0                0
## artistNameyot club                0                0
##                                genreasian pop genrebaroque pop
```

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## artistNamemokita	0	0
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## artistNamepowfu	0	0
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## artistNameradwimps	1	0
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## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	1
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	0
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## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
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## artistNameshawn mendes	0	0
## artistNameskrillex	0	1
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0
## artistNameuttam singh	1	0
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## artistNamexxxxtentacion	0	0
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## artistNameyot club	0	0
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## artistNamelund	0	0
## artistNamemokita	0	1
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## artistNameshawn mendes	1	0
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## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	-1
## artistNamethe presets	0	0

## artistNameuttam singh	0	0	
## artistNamevampire weekend	0	0	
## artistNameexxtentacion	0	0	
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## artistNameyot club	0	0	
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## artistNamenickelback	0	0	0
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## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNameexxtentacion	0	0	0
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## artistNamemokita	0	0	0
## artistNamenickelback	0	0	0
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## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
## artistNameexxtentacion	0	1	0
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## artistNameyot club	1	0	0
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## artistNamemokita	0	0	0
## artistNamenickelback	0	0	1
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	0	0	0

## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	0	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
## artistNameuttam singh	0	0	0
## artistNamevampire weekend	0	0	0
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## artistNamelund	0	0	0
## artistNamemokita	0	0	0
## artistNamenickelback	0	0	0
## artistNamepowfu	0	0	0
## artistNamepyotr ilyich tchaikovsky	0	0	0
## artistNameradwimps	0	0	0
## artistNameshawn mendes	0	0	0
## artistNameskrillex	0	0	0
## artistNamethe lumineers	0	1	0
## artistNamethe neighbourhood	-1	-1	-1
## artistNamethe presets	0	0	0
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## artistNamevampire weekend	0	0	0
## artistNamexxxxtentacion	0	0	0
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## artistNamelund	0	0	
## artistNamemokita	0	0	
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## artistName	vampire weekend	0

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## artistNamemokita	0	0
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## artistNamepowfu	0	0
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## artistNamelund	0	0

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## artistNamenickelback	0	0
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## artistNamethe lumineers	0	0
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## artistNamethe presets	0	0
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## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
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## artistNameradwimps	0	0
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## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	-1	0
## artistNamethe presets	0	0
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## artistNamenickelback 0
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## artistNameradwimps 0
## artistNameshawn mendes 0
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNamexxxxtentacion 0
## artistNameyasumu 0
## artistNameyot club -1
## artistNamecharlotte lawrence
## artistNamedimension 32 0
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## artistNamelow roar 0
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## artistNameradwimps 0 0
## artistNameshawn mendes 0 0
## artistNameskrillex 0 0
## artistNamethe lumineers 0 0
## artistNamethe neighbourhood 0 0
## artistNamethe presets 0 0
## artistNameuttam singh 0 0
## artistNamevampire weekend 0 0
## artistNamexxxxtentacion 0 0
## artistNameyasumu 0 0
## artistNameyot club -1 -1
## artistNamemaroon 5 artistNamemarshmello

```


## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	-1
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	-1	0
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## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	-1	0
## artistNamethe neighbourhood	0	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNamexxxxtentacion	0	0
## artistNameyasumu	0	0
## artistNameyot club	0	-1
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## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
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## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	0
## artistNamethe presets	0	0

## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	-1	0
## artistNameyasumu	0	0
## artistNameeyot club	0	-1
##	artistNameolivia rodrigo artistNameOther	
## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	0
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameeyot club	-1	-1
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## artistNamedimension 32	0	0
## artistNamehiroyuki sawano	0	0
## artistNamelow roar	0	0
## artistNamelund	0	0
## artistNamemokita	0	0
## artistNamenickelback	0	0
## artistNamepowfu	0	0
## artistNamepyotr ilyich tchaikovsky	0	0
## artistNameradwimps	0	0
## artistNameshawn mendes	0	0
## artistNameskrillex	0	0
## artistNamethe lumineers	0	0
## artistNamethe neighbourhood	0	-1
## artistNamethe presets	0	0
## artistNameuttam singh	0	0
## artistNamevampire weekend	0	0
## artistNameexxtentacion	0	0
## artistNameyasumu	0	0
## artistNameeyot club	-1	0
##	artistNamesachin-jigar	
## artistNamedimension 32	0	
## artistNamehiroyuki sawano	0	
## artistNamelow roar	0	
## artistNamelund	0	
## artistNamemokita	0	
## artistNamenickelback	0	
## artistNamepowfu	0	
## artistNamepyotr ilyich tchaikovsky	0	

## artistNameradwimps	0
## artistNameshawn mendes	0
## artistNameskrillex	0
## artistNamethe lumineers	0
## artistNamethe neighbourhood	0
## artistNamethe presets	0
## artistNameuttam singh	0
## artistNamevampire weekend	0
## artistNameexxtentacion	0
## artistNameyasumu	0
## artistNameyot club	-1
##	artistNamesarcastic sounds
## artistNamedimension 32	0
## artistNamehiroyuki sawano	0
## artistNamelow roar	0
## artistNamelund	0
## artistNamemokita	0
## artistNamenickelback	0
## artistNamepowfu	0
## artistNamepyotr ilyich tchaikovsky	0
## artistNameradwimps	0
## artistNameshawn mendes	0
## artistNameskrillex	0
## artistNamethe lumineers	0
## artistNamethe neighbourhood	0
## artistNamethe presets	0
## artistNameuttam singh	0
## artistNamevampire weekend	0
## artistNameexxtentacion	0
## artistNameyasumu	-1
## artistNameyot club	0
##	artistNamesasha alex sloan
## artistNamedimension 32	0
## artistNamehiroyuki sawano	0
## artistNamelow roar	0
## artistNamelund	0
## artistNamemokita	0
## artistNamenickelback	0
## artistNamepowfu	0
## artistNamepyotr ilyich tchaikovsky	0
## artistNameradwimps	0
## artistNameshawn mendes	0
## artistNameskrillex	0
## artistNamethe lumineers	0
## artistNamethe neighbourhood	-1
## artistNamethe presets	0
## artistNameuttam singh	0
## artistNamevampire weekend	0
## artistNameexxtentacion	0
## artistNameyasumu	0
## artistNameyot club	0
##	artistNameshankar-ehsaan-loy
## artistNamedimension 32	0
## artistNamehiroyuki sawano	0

## artistName	low roar	0
## artistName	lund	0
## artistName	mokita	0
## artistName	nickelback	0
## artistName	powfu	0
## artistName	pyotr ilyich tchaikovsky	0
## artistName	radwimps	0
## artistName	shawn mendes	0
## artistName	skrillex	0
## artistName	the lumineers	0
## artistName	the neighbourhood	0
## artistName	the presets	0
## artistName	uttam singh	0
## artistName	vampire weekend	0
## artistName	xxxxtentacion	0
## artistName	yasumi	0
## artistName	yot club	-1
##	artistName	shreya ghoshal artistName
## artistName	dimension 32	0 0
## artistName	hiroyuki sawano	0 0
## artistName	low roar	0 0
## artistName	lund	0 0
## artistName	mokita	0 0
## artistName	nickelback	0 0
## artistName	powfu	0 0
## artistName	pyotr ilyich tchaikovsky	0 0
## artistName	radwimps	0 0
## artistName	shawn mendes	0 0
## artistName	skrillex	0 0
## artistName	the lumineers	0 0
## artistName	the neighbourhood	0 -1
## artistName	the presets	0 0
## artistName	uttam singh	0 0
## artistName	vampire weekend	0 0
## artistName	xxxxtentacion	0 0
## artistName	yasumi	0 0
## artistName	yot club	-1 0
##	artistName	sonu nigam artistName
## artistName	dimension 32	0 0
## artistName	hiroyuki sawano	0 0
## artistName	low roar	0 0
## artistName	lund	0 0
## artistName	mokita	0 0
## artistName	nickelback	0 0
## artistName	powfu	0 0
## artistName	pyotr ilyich tchaikovsky	0 0
## artistName	radwimps	0 0
## artistName	shawn mendes	0 0
## artistName	skrillex	0 0
## artistName	the lumineers	0 0
## artistName	the neighbourhood	0 0
## artistName	the presets	0 0
## artistName	uttam singh	0 0
## artistName	vampire weekend	0 0

##	artistNameexxtentacion	0	0
##	artistNameyasumu	0	0
##	artistNameyot club	-1	-1
##		artistNametate mcrae	artistNametaylor swift
##	artistNamedimension 32	0	0
##	artistNamehiroyuki sawano	0	0
##	artistNamelow roar	0	0
##	artistNamelund	0	0
##	artistNamemokita	0	0
##	artistNamenickelback	0	0
##	artistNamepowfu	0	0
##	artistNamepyotr ilyich tchaikovsky	0	0
##	artistNameradwimps	0	0
##	artistNameshawn mendes	0	0
##	artistNameskrillex	0	0
##	artistNameethe lumineers	0	0
##	artistNameethe neighbourhood	-1	0
##	artistNameethe presets	0	0
##	artistNameuttam singh	0	0
##	artistNamevampire weekend	0	0
##	artistNameexxtentacion	0	0
##	artistNameyasumu	0	0
##	artistNameyot club	0	-1
##		artistNametwenty one pilots	
##	artistNamedimension 32	0	
##	artistNamehiroyuki sawano	0	
##	artistNamelow roar	0	
##	artistNamelund	0	
##	artistNamemokita	0	
##	artistNamenickelback	0	
##	artistNamepowfu	0	
##	artistNamepyotr ilyich tchaikovsky	0	
##	artistNameradwimps	0	
##	artistNameshawn mendes	0	
##	artistNameskrillex	0	
##	artistNameethe lumineers	0	
##	artistNameethe neighbourhood	0	
##	artistNameethe presets	0	
##	artistNameuttam singh	0	
##	artistNamevampire weekend	0	
##	artistNameexxtentacion	0	
##	artistNameyasumu	0	
##	artistNameyot club	-1	
##		artistNamewhy don't we	
##	artistNamedimension 32	0	
##	artistNamehiroyuki sawano	0	
##	artistNamelow roar	0	
##	artistNamelund	0	
##	artistNamemokita	0	
##	artistNamenickelback	0	
##	artistNamepowfu	0	
##	artistNamepyotr ilyich tchaikovsky	0	
##	artistNameradwimps	0	
##	artistNameshawn mendes	0	

```
## artistNameskrillex 0
## artistNamethe lumineers 0
## artistNamethe neighbourhood 0
## artistNamethe presets 0
## artistNameuttam singh 0
## artistNamevampire weekend 0
## artistNamexxxxtentacion 0
## artistNameyasumu 0
## artistNameyot club 0
```

```
# Step 2: Extract Names of Aliased Variables
# Identify columns with linear dependencies (non-zero values in alias matrix)
aliased_vars <- colnames(alias_matrix)[apply(alias_matrix, 2, function(x) any(x != 0))]
print(aliased_vars) # Print the aliased variables for review
```

```
## [1] "(Intercept)" "genrealternative dance"
## [3] "genreanime score" "genreasian pop"
## [5] "genrebaroque pop" "genrebollywood"
## [7] "genreboy band" "genrebrostep"
## [9] "genrecanadian pop" "genrechill pop"
## [11] "genreclassical" "genrecloud rap"
## [13] "genreedm" "genrefilmi"
## [15] "genrehip hop" "genreicelandic indie"
## [17] "genrelo-fi" "genrelo-fi sleep"
## [19] "genremetal" "genremodern rock"
## [21] "genreOther" "genrepop"
## [23] "genresad lo-fi" "artistNamea.r. rahman"
## [25] "artistNameaj mitchell" "artistNamealec benjamin"
## [27] "artistNamealice in chains" "artistNameanson seabra"
## [29] "artistNameap dhillon" "artistNamearijit singh"
## [31] "artistNameastrid s" "artistNameau/ra"
## [33] "artistNameaurora" "artistNamebazzi"
## [35] "artistNameber" "artistNamebesomorph"
## [37] "artistNamebillie eilish" "artistNameblackbear"
## [39] "artistNameboy in space" "artistNamebülöw"
## [41] "artistNamecalvin harris" "artistNamecharlie puth"
## [43] "artistNamecharlotte gainsbourg" "artistNamecharlotte lawrence"
## [45] "artistNamechris james" "artistNamechristine and the queens"
## [47] "artistNamechromatics" "artistNameclaudie debussy"
## [49] "artistNameclean bandit" "artistNamecolours in the dark"
## [51] "artistNameconan gray" "artistNameconnor price"
## [53] "artistNamedaya" "artistNamedj snake"
## [55] "artistNamedoja cat" "artistNameed sheeran"
## [57] "artistNameealley duhé" "artistNameenrique iglesias"
## [59] "artistNameefiji blue" "artistNamefinneas"
## [61] "artistNameeflo rida" "artistNamefly by midnight"
## [63] "artistNameegerardo millán" "artistNameehans zimmer"
## [65] "artistNameeharry styles" "artistNameehrvy"
## [67] "artistNameeillenium" "artistNameeimage dragons"
## [69] "artistNamejack ü" "artistNamejames arthur"
## [71] "artistNamejason mraz" "artistNamejatin-lalit"
## [73] "artistNamejeremy zucker" "artistNamejohn k"
## [75] "artistNamejonas blue" "artistNamejordy chandra"
## [77] "artistNamejosh golden" "artistNamejp saxe"
```

```
## [79] "artistNamejulia michael"      "artistNamejustin bieber"
## [81] "artistNamejvke"                "artistNamekainbeats"
## [83] "artistNamekato"                "artistNamekhalid"
## [85] "artistNamekina"                "artistNamekishore kumar"
## [87] "artistNamekk"                  "artistNamekyu"
## [89] "artistNamelady gaga"           "artistNamelany"
## [91] "artistNamelauv"                "artistNamelinearwave"
## [93] "artistNamelinkin park"         "artistNamelizzy mcalpine"
## [95] "artistNameludwig van beethoven" "artistNamelmajor lazer"
## [97] "artistNamemark ambor"          "artistNamelmaroon 5"
## [99] "artistNamelmarshmello"         "artistNamelmc orsen"
## [101] "artistNamelunn"                "artistNamenf"
## [103] "artistNamenic d"               "artistNameolivia rodrigo"
## [105] "artistNameOther"               "artistNamepritam"
## [107] "artistNameruel"                "artistNamesachin-jigar"
## [109] "artistNamesarcastic sounds"    "artistNamesasha alex sloan"
## [111] "artistNameshankar-ehsaan-loy"  "artistNameshreya ghoshal"
## [113] "artistNamesody"                "artistNamesonu nigam"
## [115] "artistNamestephen"             "artistNamelate mcrae"
## [117] "artistNamelataylor swift"      "artistNameltwenty one pilots"
```

```
# Check the column names to confirm available variables
colnames(spotify_analysis_data)
```

```
## [1] "trackName"      "msPlayed"        "danceability"    "danceability_imp"
## [5] "energy"          "energy_imp"      "tempo"           "tempo_imp"
## [9] "genre"          "artistName"
```

```
# Update the model formula with valid column names
# Replace 'acousticness' with the correct variable if it exists under a different name
spotify_model <- lm(msPlayed ~ danceability + energy + genre + artistName, data = spotify_analysis_data)
summary(spotify_model)
```

```
##
## Call:
## lm(formula = msPlayed ~ danceability + energy + genre + artistName,
##     data = spotify_analysis_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -16716989 -1305652  -765655  -2043 150699562
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    9.379e+05  2.559e+06   0.366  0.714016
## danceability   -2.168e+05  3.057e+05  -0.709  0.478242
## energy         -2.584e+05  2.684e+05  -0.962  0.335824
## genrealternative  1.968e+06  2.158e+06   0.912  0.361847
## genrealternative dance  4.191e+05  2.293e+06   0.183  0.854987
## genrealternative score -2.847e+05  3.027e+06  -0.094  0.925065
## genrealternative pop    1.157e+06  2.263e+06   0.511  0.609221
## genrealternative baroque pop  7.161e+05  3.397e+06   0.211  0.833071
## genrealternative bollywood  2.283e+05  2.374e+06   0.096  0.923399
```

## genreboy band	8.916e+05	2.293e+06	0.389	0.697356
## genrebrostep	5.162e+05	2.288e+06	0.226	0.821528
## genrecanadian pop	4.783e+05	3.048e+06	0.157	0.875298
## genrechill pop	1.643e+06	2.441e+06	0.673	0.500936
## genreclassical	2.618e+05	2.220e+06	0.118	0.906105
## genrecloud rap	6.025e+05	2.555e+06	0.236	0.813620
## genredesi pop	4.041e+05	2.236e+06	0.181	0.856543
## genredrift phonk	2.768e+05	2.194e+06	0.126	0.899578
## genreedm	1.299e+06	2.214e+06	0.587	0.557403
## genreelectronic	1.043e+05	3.022e+06	0.035	0.972467
## genrefilmi	5.865e+05	2.179e+06	0.269	0.787785
## genrefolk	1.556e+06	2.301e+06	0.676	0.498795
## genregen z singer-songwriter	3.867e+06	2.240e+06	1.726	0.084302
## genrehip hop	4.461e+05	2.202e+06	0.203	0.839433
## genreicelandic indie	-9.031e+06	2.758e+06	-3.274	0.001063 **
## genreindian	2.891e+05	2.829e+06	0.102	0.918589
## genreindie	1.011e+06	2.253e+06	0.449	0.653553
## genrelo-fi	5.071e+05	2.195e+06	0.231	0.817303
## genrelo-fi sleep	6.702e+04	2.289e+06	0.029	0.976641
## genremetal	9.168e+05	2.324e+06	0.395	0.693209
## genremodern rock	1.131e+06	2.570e+06	0.440	0.659714
## genreOther	1.240e+06	2.140e+06	0.580	0.562097
## genrepop	1.534e+06	2.150e+06	0.713	0.475735
## genrepost-rock	-7.948e+04	3.026e+06	-0.026	0.979044
## generock	1.657e+06	2.237e+06	0.741	0.458830
## genresad lo-fi	1.453e+06	2.371e+06	0.613	0.540007
## genrevgm	-1.868e+05	4.280e+06	-0.044	0.965190
## artistNamea.r. rahman	-1.189e+06	1.886e+06	-0.630	0.528608
## artistNameaj mitchell	-7.519e+05	2.073e+06	-0.363	0.716840
## artistNameakano	-8.104e+05	2.163e+06	-0.375	0.707860
## artistNamealan walker	-8.710e+05	1.974e+06	-0.441	0.658988
## artistNamealec benjamin	-1.642e+06	1.559e+06	-1.053	0.292354
## artistNameali gatie	1.333e+06	2.054e+06	0.649	0.516564
## artistNamealice in chains	-1.226e+06	2.340e+06	-0.524	0.600447
## artistNameandré rieu	1.514e+06	1.915e+06	0.791	0.429193
## artistNameanson seabra	4.296e+05	2.074e+06	0.207	0.835893
## artistNameap dhillon	4.684e+06	1.859e+06	2.519	0.011776 *
## artistNamearijit singh	-1.068e+06	1.994e+06	-0.536	0.592269
## artistNameastrid s	-1.096e+06	2.181e+06	-0.503	0.615311
## artistNameau/ra	-1.145e+06	2.181e+06	-0.525	0.599400
## artistNameaurora	-9.007e+05	1.919e+06	-0.469	0.638822
## artistNamebazzi	-1.245e+06	1.831e+06	-0.680	0.496767
## artistNameber	-5.598e+05	1.988e+06	-0.282	0.778226
## artistNamebesomorph	-2.227e+06	2.181e+06	-1.021	0.307199
## artistNamebillie eilish	-1.845e+06	2.174e+06	-0.849	0.396170
## artistNameblackbear	-1.377e+06	1.482e+06	-0.929	0.352718
## artistNameboy in space	1.758e+05	1.993e+06	0.088	0.929716
## artistNamebülow	-5.737e+05	2.181e+06	-0.263	0.792558
## artistNamecalvin harris	-1.853e+06	2.067e+06	-0.896	0.370127
## artistNamecharlie puth	3.295e+05	1.549e+06	0.213	0.831551
## artistNamecharlotte gainsbourg	-1.434e+06	1.872e+06	-0.766	0.443593
## artistNamecharlotte lawrence	9.068e+01	2.181e+06	0.000	0.999967
## artistNamechase atlantic	-1.576e+06	2.162e+06	-0.729	0.466141
## artistNamechildish gambino	-5.189e+05	1.860e+06	-0.279	0.780241

## artistNamechris james	4.004e+05	2.067e+06	0.194	0.846394
## artistNamechristine and the queens	-1.892e+06	2.066e+06	-0.915	0.359954
## artistNamechromatics	-8.187e+05	2.314e+06	-0.354	0.723485
## artistNameclaudio debussy	-1.002e+06	2.234e+06	-0.449	0.653691
## artistNameclean bandit	-1.830e+06	2.174e+06	-0.842	0.400041
## artistNamecolours in the dark	-4.321e+05	2.205e+06	-0.196	0.844679
## artistNameconan gray	-4.008e+04	1.922e+06	-0.021	0.983367
## artistNameconnor price	-4.543e+05	2.176e+06	-0.209	0.834579
## artistNameconro	-1.123e+05	1.912e+06	-0.059	0.953177
## artistNamecurtis schweitzer	-1.442e+06	1.976e+06	-0.730	0.465571
## artistNamedaya	1.558e+06	2.174e+06	0.717	0.473442
## artistNamedevin kennedy	4.156e+05	2.162e+06	0.192	0.847614
## artistNamediljit dosanjh	-7.269e+05	2.187e+06	-0.332	0.739581
## artistNamedimension 32	2.600e+05	1.988e+06	0.131	0.895953
## artistNamedj shadow	1.784e+05	2.164e+06	0.082	0.934293
## artistNamedj snake	-1.212e+06	2.132e+06	-0.568	0.569859
## artistNamedoja cat	-1.982e+06	2.174e+06	-0.911	0.362118
## artistNameearth, wind & fire	5.655e+05	1.974e+06	0.287	0.774488
## artistNameed sheeran	-1.229e+06	1.700e+06	-0.723	0.469755
## artistNameeeden	1.176e+06	2.162e+06	0.544	0.586484
## artistNameelley duhé	-1.152e+06	2.074e+06	-0.555	0.578662
## artistNameeminem	1.933e+06	1.644e+06	1.175	0.239920
## artistNameenrique iglesias	1.575e+06	2.175e+06	0.724	0.468932
## artistNameeve	2.042e+06	1.755e+06	1.164	0.244626
## artistNameewan j phillips	3.921e+05	1.755e+06	0.223	0.823268
## artistNameefiji blue	-7.590e+05	2.297e+06	-0.330	0.741064
## artistNameefinneas	2.340e+06	1.778e+06	1.317	0.188021
## artistNameeflo rida	-1.952e+06	2.174e+06	-0.898	0.369391
## artistNameefly by midnight	-3.027e+04	2.065e+06	-0.015	0.988308
## artistNameegerardo millán	-9.634e+05	2.111e+06	-0.456	0.648162
## artistNameeglaive	5.905e+05	1.689e+06	0.350	0.726635
## artistNameeglass animals	1.072e+05	2.163e+06	0.050	0.960478
## artistNameegreen day	-1.597e+06	2.441e+06	-0.654	0.513124
## artistNameehans zimmer	1.791e+06	1.627e+06	1.101	0.271020
## artistNameeharry styles	1.924e+06	2.173e+06	0.885	0.375955
## artistNameehigh school musical cast	-1.487e+06	1.756e+06	-0.847	0.397124
## artistNameehiroyuki sawano	2.361e+06	2.652e+06	0.890	0.373445
## artistNameehrvy	-7.419e+05	1.923e+06	-0.386	0.699656
## artistNameeillenium	-8.173e+05	2.236e+06	-0.366	0.714734
## artistNameeimage dragons	-1.382e+06	2.256e+06	-0.612	0.540234
## artistNameejack ü	-1.068e+06	2.032e+06	-0.526	0.599117
## artistNameejaden	2.775e+06	1.754e+06	1.582	0.113709
## artistNameejames arthur	-2.079e+06	1.985e+06	-1.047	0.295036
## artistNameejason mrz	5.157e+05	2.173e+06	0.237	0.812385
## artistNameejatin-lalit	-1.861e+06	1.985e+06	-0.938	0.348351
## artistNameejeremy zucker	-1.532e+06	1.806e+06	-0.848	0.396351
## artistNameejohn k	-1.093e+06	1.922e+06	-0.569	0.569461
## artistNameejoji	2.315e+06	1.973e+06	1.173	0.240702
## artistNameejonas blue	-1.469e+06	1.658e+06	-0.886	0.375606
## artistNameejordy chandra	-1.117e+06	2.032e+06	-0.550	0.582629
## artistNameejosh golden	1.306e+06	1.721e+06	0.759	0.447785
## artistNameejp saxe	-1.513e+06	2.180e+06	-0.694	0.487799
## artistNameejulia michaelis	-1.508e+06	2.065e+06	-0.730	0.465194
## artistNameejustin bieber	-6.753e+05	2.774e+06	-0.243	0.807675

## artistNamejvke	8.404e+05	2.096e+06	0.401	0.688487	
## artistNamekainbeats	-1.082e+06	2.217e+06	-0.488	0.625388	
## artistNamekanye west	-1.064e+06	2.054e+06	-0.518	0.604505	
## artistNamekato	-1.113e+06	1.590e+06	-0.700	0.483953	
## artistNamekeshi	-1.377e+06	2.054e+06	-0.671	0.502543	
## artistNamekhalid	5.880e+05	2.173e+06	0.271	0.786711	
## artistNamekina	-1.065e+06	2.222e+06	-0.479	0.631822	
## artistNamekishore kumar	-4.318e+05	2.394e+06	-0.180	0.856850	
## artistNamekk	-7.833e+05	1.581e+06	-0.495	0.620376	
## artistNamekute	-1.537e+06	2.057e+06	-0.747	0.455021	
## artistNamekygo	1.513e+07	2.209e+06	6.850	7.84e-12	***
## artistNamekyu	-1.135e+06	2.217e+06	-0.512	0.608542	
## artistNamelabrinth	-8.711e+05	2.162e+06	-0.403	0.687068	
## artistNamelady gaga	-1.785e+06	2.175e+06	-0.821	0.411848	
## artistNamelany	1.241e+06	2.173e+06	0.571	0.567941	
## artistNamelauv	-2.221e+04	1.501e+06	-0.015	0.988199	
## artistNamelil nas x	3.148e+05	1.911e+06	0.165	0.869163	
## artistNamelinearwave	-1.124e+06	2.033e+06	-0.553	0.580277	
## artistNamelinkin park	-1.254e+06	1.740e+06	-0.721	0.471195	
## artistNamelizzy mcalpine	2.570e+06	2.181e+06	1.178	0.238692	
## artistNamelorn	-1.557e+06	2.054e+06	-0.758	0.448369	
## artistNamelow roar	1.065e+07	2.166e+06	4.917	8.95e-07	***
## artistNameludwig van beethoven	-1.351e+06	2.013e+06	-0.671	0.502089	
## artistNamelund	2.171e+06	2.036e+06	1.066	0.286398	
## artistName83	-1.111e+06	1.861e+06	-0.597	0.550439	
## artistNamemajor lazer	-2.038e+06	2.174e+06	-0.938	0.348424	
## artistNamemarco luka	1.404e+06	2.162e+06	0.649	0.516250	
## artistNamemark ambor	-1.890e+06	1.981e+06	-0.954	0.340048	
## artistNamemaroon 5	-1.440e+06	1.923e+06	-0.749	0.454017	
## artistNamemarshmello	-5.898e+05	2.073e+06	-0.285	0.776018	
## artistNamemartin garrix	-9.239e+05	2.054e+06	-0.450	0.652918	
## artistNamematt maltese	7.860e+05	1.859e+06	0.423	0.672512	
## artistNamemc orsen	-3.529e+05	2.216e+06	-0.159	0.873483	
## artistNamemichiel schrey	-1.797e+06	2.163e+06	-0.830	0.406297	
## artistNamemike shinoda	-5.584e+05	1.911e+06	-0.292	0.770105	
## artistNamemj apanay	-1.922e+06	2.054e+06	-0.936	0.349393	
## artistNamemokita	3.411e+06	1.887e+06	1.808	0.070660	.
## artistNamemoondeity	-1.076e+06	2.057e+06	-0.523	0.601065	
## artistNamemunnn	8.053e+05	1.982e+06	0.406	0.684453	
## artistNameeffex	-9.746e+05	2.164e+06	-0.450	0.652437	
## artistNamenf	2.860e+05	1.684e+06	0.170	0.865167	
## artistNamenic d	-1.121e+06	2.174e+06	-0.516	0.606135	
## artistNamenickelback	-4.954e+05	2.240e+06	-0.221	0.825005	
## artistNamenico collins	-2.830e+05	1.601e+06	-0.177	0.859676	
## artistNamenirvana	-1.458e+06	2.164e+06	-0.674	0.500488	
## artistNamenodisco.	2.115e+05	1.973e+06	0.107	0.914662	
## artistNameodesza	-1.932e+05	1.642e+06	-0.118	0.906359	
## artistNameolivia rodrigo	-6.805e+05	2.173e+06	-0.313	0.754124	
## artistNameonerepublic	-1.034e+06	1.861e+06	-0.556	0.578293	
## artistNameOther	-5.198e+05	1.389e+06	-0.374	0.708289	
## artistNamepj harvey	-1.699e+06	2.162e+06	-0.785	0.432200	
## artistNamepost malone	-9.007e+05	1.729e+06	-0.521	0.602474	
## artistNamepowfu	-7.293e+05	2.295e+06	-0.318	0.750630	
## artistNamepritam	-9.570e+05	1.593e+06	-0.601	0.548088	

```
## artistNamepyotr ilyich tchaikovsky 5.125e+05 2.052e+06 0.250 0.802756
## artistNameradwimps 5.724e+06 1.677e+06 3.413 0.000645 ***
## artistNameruel -1.858e+05 1.677e+06 -0.111 0.911790
## artistNamesachin-jigar -1.143e+06 2.015e+06 -0.567 0.570633
## artistNamesam smith -1.181e+06 2.169e+06 -0.544 0.586245
## artistNamesarcastic sounds -5.160e+05 1.924e+06 -0.268 0.788623
## artistNamesasha alex sloan 5.137e+05 1.568e+06 0.328 0.743198
## artistNamesean dagher -1.758e+06 2.055e+06 -0.855 0.392354
## artistNameshankar-ehsaan-loy -8.766e+05 1.864e+06 -0.470 0.638107
## artistNameshawn mendes -5.262e+05 2.659e+06 -0.198 0.843121
## artistNameshockwave-sound 1.184e+06 2.055e+06 0.576 0.564600
## artistNameshreya ghoshal -1.005e+06 2.094e+06 -0.480 0.631458
## artistNameskrillex -8.765e+05 1.748e+06 -0.501 0.616132
## artistNamesody -4.153e+05 2.180e+06 -0.190 0.848951
## artistNamesonu nigam -1.003e+06 1.564e+06 -0.641 0.521348
## artistNamestephen 1.146e+06 1.982e+06 0.578 0.562949
## artistNamesurfaces -1.121e+06 2.164e+06 -0.518 0.604442
## artistNametate mcrae 1.634e+05 1.840e+06 0.089 0.929227
## artistNametaylor swift -1.447e+06 1.985e+06 -0.729 0.465964
## artistNamethe chainsmokers -1.413e+06 1.974e+06 -0.716 0.474129
## artistNamethe kid laroi -7.051e+05 2.162e+06 -0.326 0.744336
## artistNamethe lumineers -6.078e+05 2.321e+06 -0.262 0.793471
## artistNamethe neighbourhood -1.261e+06 1.528e+06 -0.825 0.409542
## artistNamethe presets -3.131e+05 2.213e+06 -0.142 0.887469
## artistNamethe weeknd -5.030e+05 1.671e+06 -0.301 0.763466
## artistNametwenty one pilots -8.422e+04 2.171e+06 -0.039 0.969055
## artistNameunlike pluto -4.752e+05 1.974e+06 -0.241 0.809720
## artistNameuttam singh -5.341e+05 1.972e+06 -0.271 0.786561
## artistNamevalorant 1.388e+06 2.164e+06 0.642 0.521127
## artistNamevampire weekend -1.107e+06 2.981e+06 -0.371 0.710275
## artistNamevishal-shekhar -1.019e+06 2.187e+06 -0.466 0.641305
## artistNamewhy don't we -9.204e+05 1.996e+06 -0.461 0.644712
## artistNamewillis -4.432e+05 1.729e+06 -0.256 0.797708
## artistNamewinona oak 2.227e+05 1.860e+06 0.120 0.904683
## artistNameexxtentacion 1.070e+05 1.892e+06 0.057 0.954918
## artistNameyasuharu takanashi -1.798e+06 1.578e+06 -1.140 0.254466
## artistNameyasumu -4.466e+05 1.650e+06 -0.271 0.786691
## artistNameyo yo honey singh -1.310e+06 1.987e+06 -0.659 0.509771
## artistNameyot club -8.195e+05 2.173e+06 -0.377 0.706082
## artistNameyunomi 3.316e+06 2.054e+06 1.614 0.106545
## artistNamezachary knowles 2.166e+05 1.973e+06 0.110 0.912595
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5233000 on 9868 degrees of freedom
## Multiple R-squared: 0.05173, Adjusted R-squared: 0.03146
## F-statistic: 2.551 on 211 and 9868 DF, p-value: < 2.2e-16
```

Now that we got rid of the Alias Variables, Let's Proceed with: `###` Calculation of Variance Inflation Factor -

```
# Calculate Variance Inflation Factor (VIF)
vif_values <- vif(spotify_model)
```

```
# Print the VIF values
print(vif_values)
```

```
##              GVIF  Df GVIF^(1/(2*Df))
## danceability 1.364134e+00  1      1.167961
## energy       1.565292e+00  1      1.251116
## genre        4.903460e+11 33      1.503588
## artistName   5.047603e+11 176     1.079562
```

```
# Identify predictors with high VIF (e.g., >5)
high_vif <- names(vif_values[vif_values > 5])

cat("Predictors with high VIF:", high_vif, "\n")
```

```
## Predictors with high VIF:
```

As we can see, no GVIF values exceed 5, indicating there is no Multicollinearity now.

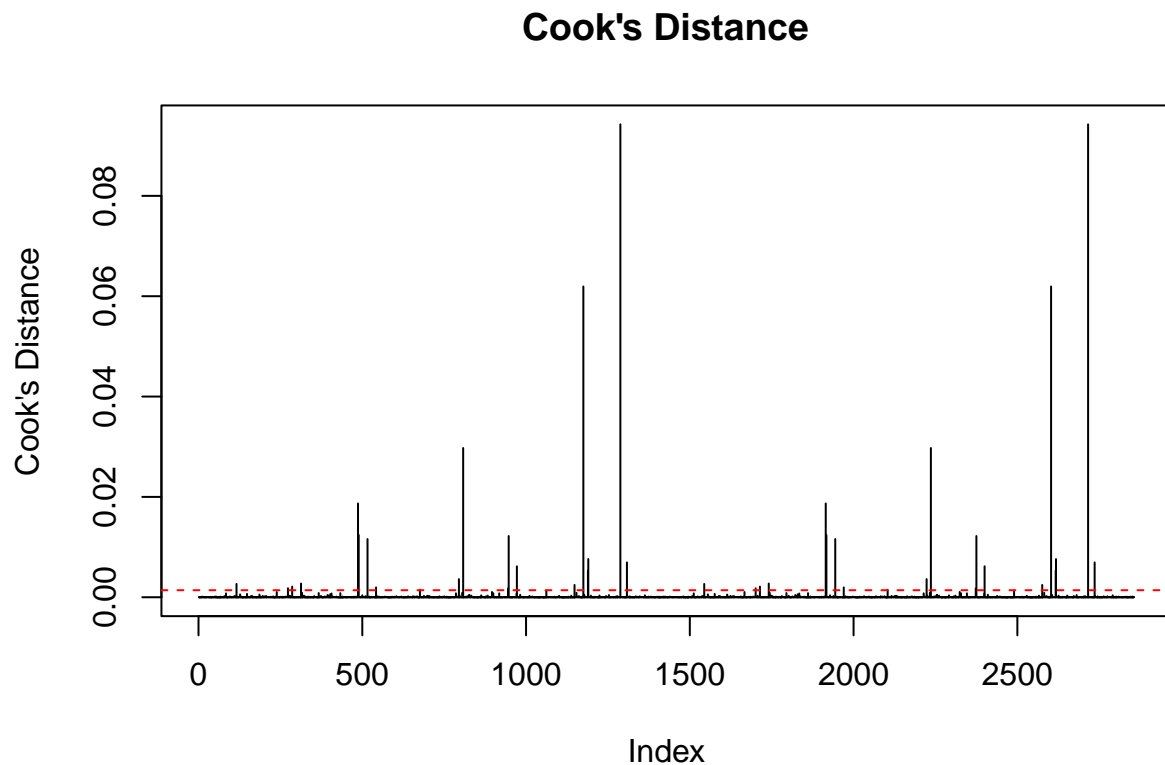
Which brings us to the next step -

3. Check for Influential Points.

```
# Cook's Distance
cooks_distances <- cooks.distance(model)

# Leverage values
leverage_values <- hatvalues(model)

# Plot Cook's Distance
plot(cooks_distances, type = "h", main = "Cook's Distance", ylab = "Cook's Distance")
abline(h = 4 / nrow(spotify_analysis_data_filtered), col = "red", lty = 2) # Threshold line
```



```
# Identify high Cook's Distance
influential_points_cooks <- which(cooks_distances > (4 / nrow(spotify_analysis_data_filtered)))
print("Influential Points (Cook's Distance):")
```

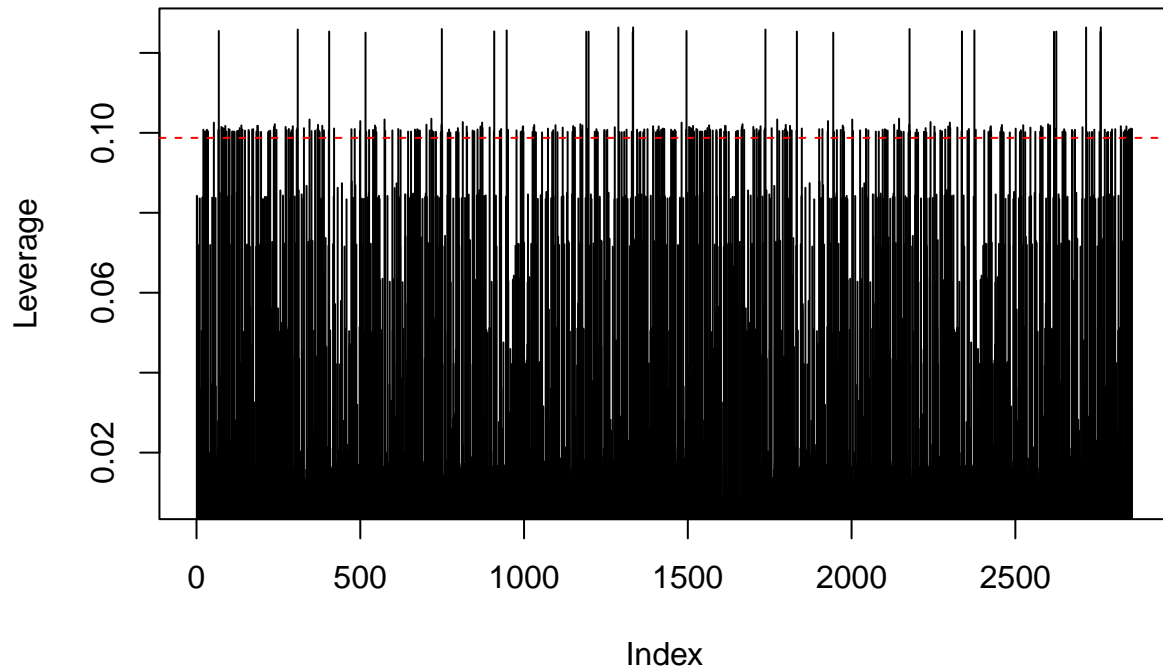
```
## [1] "Influential Points (Cook's Distance):"
```

```
print(influential_points_cooks)
```

```
## 116 273 286 313 487 489 516 542 676 795 808 945 947 972 1148 1175
## 116 273 286 313 487 489 516 542 676 795 808 945 947 972 1148 1175
## 1189 1190 1288 1308 1544 1701 1714 1741 1915 1917 1944 1970 2104 2223 2236 2373
## 1189 1190 1288 1308 1544 1701 1714 1741 1915 1917 1944 1970 2104 2223 2236 2373
## 2375 2400 2576 2603 2617 2618 2716 2736
## 2375 2400 2576 2603 2617 2618 2716 2736
```

```
# Plot Leverage values
plot(leverage_values, type = "h", main = "Leverage Values", ylab = "Leverage")
abline(h = 2 * (length(coefficients(model)) / nrow(spotify_analysis_data_filtered)), col = "red", lty =
```

Leverage Values



```
# Identify high Leverage Points
```

```
influential_points_leverage <- which(leverage_values > (2 * (length(coefficients(model)) / nrow(spotify.  
print("Influential Points (Leverage):")
```

```
## [1] "Influential Points (Leverage):"
```

```
print(influential_points_leverage)
```

```
## 21 26 29 32 35 53 67 68 76 80 84 88 91 98 101 109
## 21 26 29 32 35 53 67 68 76 80 84 88 91 98 101 109
## 110 112 115 116 124 127 130 132 137 140 148 159 160 170 173 183
## 110 112 115 116 124 127 130 132 137 140 148 159 160 170 173 183
## 186 187 189 197 219 220 221 225 236 237 238 239 244 272 275 282
## 186 187 189 197 219 220 221 225 236 237 238 239 244 272 275 282
## 288 290 292 294 306 308 309 328 345 351 362 369 371 373 376 384
## 288 290 292 294 306 308 309 328 345 351 362 369 371 373 376 384
## 389 404 405 420 473 483 499 500 516 518 527 539 545 547 549 574
## 389 404 405 420 473 483 499 500 516 518 527 539 545 547 549 574
## 576 598 616 623 646 655 667 673 674 677 678 682 702 712 717 719
## 576 598 616 623 646 655 667 673 674 677 678 682 702 712 717 719
## 724 731 746 747 748 749 750 767 771 775 793 794 798 800 813 825
## 724 731 746 747 748 749 750 767 771 775 793 794 798 800 813 825
## 826 843 846 848 858 867 872 873 895 908 909 926 929 930 947 951
## 826 843 846 848 858 867 872 873 895 908 909 926 929 930 947 951
## 977 990 994 995 996 997 998 1026 1029 1031 1035 1036 1055 1073 1086 1089
```

```
## 977 990 994 995 996 997 998 1026 1029 1031 1035 1036 1055 1073 1086 1089
## 1096 1102 1118 1133 1148 1150 1154 1155 1172 1177 1178 1190 1193 1197 1216 1219
## 1096 1102 1118 1133 1148 1150 1154 1155 1172 1177 1178 1190 1193 1197 1216 1219
## 1220 1221 1223 1225 1245 1246 1253 1254 1277 1288 1291 1298 1306 1313 1329 1332
## 1220 1221 1223 1225 1245 1246 1253 1254 1277 1288 1291 1298 1306 1313 1329 1332
## 1333 1345 1352 1355 1364 1367 1377 1394 1395 1403 1407 1411 1414 1419 1424 1428
## 1333 1345 1352 1355 1364 1367 1377 1394 1395 1403 1407 1411 1414 1419 1424 1428
## 1449 1454 1457 1460 1463 1481 1495 1496 1504 1508 1512 1516 1519 1526 1529 1537
## 1449 1454 1457 1460 1463 1481 1495 1496 1504 1508 1512 1516 1519 1526 1529 1537
## 1538 1540 1543 1544 1552 1555 1558 1560 1565 1568 1576 1587 1588 1598 1601 1611
## 1538 1540 1543 1544 1552 1555 1558 1560 1565 1568 1576 1587 1588 1598 1601 1611
## 1614 1615 1617 1625 1647 1648 1649 1653 1664 1665 1666 1667 1672 1700 1703 1710
## 1614 1615 1617 1625 1647 1648 1649 1653 1664 1665 1666 1667 1672 1700 1703 1710
## 1716 1718 1720 1722 1734 1736 1737 1756 1773 1779 1790 1797 1799 1801 1804 1812
## 1716 1718 1720 1722 1734 1736 1737 1756 1773 1779 1790 1797 1799 1801 1804 1812
## 1817 1832 1833 1848 1901 1911 1927 1928 1944 1946 1955 1967 1973 1975 1977 2002
## 1817 1832 1833 1848 1901 1911 1927 1928 1944 1946 1955 1967 1973 1975 1977 2002
## 2004 2026 2044 2051 2074 2083 2095 2101 2102 2105 2106 2110 2130 2140 2145 2147
## 2004 2026 2044 2051 2074 2083 2095 2101 2102 2105 2106 2110 2130 2140 2145 2147
## 2152 2159 2174 2175 2176 2177 2178 2195 2199 2203 2221 2222 2226 2228 2241 2253
## 2152 2159 2174 2175 2176 2177 2178 2195 2199 2203 2221 2222 2226 2228 2241 2253
## 2254 2271 2274 2276 2286 2295 2300 2301 2323 2336 2337 2354 2357 2358 2375 2379
## 2254 2271 2274 2276 2286 2295 2300 2301 2323 2336 2337 2354 2357 2358 2375 2379
## 2405 2418 2422 2423 2424 2425 2426 2454 2457 2459 2463 2464 2483 2501 2514 2517
## 2405 2418 2422 2423 2424 2425 2426 2454 2457 2459 2463 2464 2483 2501 2514 2517
## 2524 2530 2546 2561 2576 2578 2582 2583 2600 2605 2606 2618 2621 2625 2644 2647
## 2524 2530 2546 2561 2576 2578 2582 2583 2600 2605 2606 2618 2621 2625 2644 2647
## 2648 2649 2651 2653 2673 2674 2681 2682 2705 2716 2719 2726 2734 2741 2757 2760
## 2648 2649 2651 2653 2673 2674 2681 2682 2705 2716 2719 2726 2734 2741 2757 2760
## 2761 2773 2780 2783 2792 2795 2805 2822 2823 2831 2835 2839 2842 2847 2852 2856
## 2761 2773 2780 2783 2792 2795 2805 2822 2823 2831 2835 2839 2842 2847 2852 2856
```

Key Observations from the Plot:

1. High Influence Points:

- Several points exceed the critical threshold, with notable spikes in the Cook's Distance plot.
- Examples of influential points include indices 116, 273, 286, 487, 945, 1190, 2375, and 2716.

2. Concentration of Influential Points:

- Influential points are spread throughout the dataset but appear concentrated around specific ranges, which may correspond to certain patterns in the data (e.g., outliers or high-leverage observations).

3. Magnitude of Influence:

- The most influential points significantly deviate from the majority of observations, suggesting their disproportionate impact on the regression coefficients.

4. Potential Issues:

- Retaining these points may lead to biased or unstable regression estimates.
- Their presence may indicate outliers, leverage points, or model misspecifications.

5. Action Required:

- Investigate these points individually to determine their nature (e.g., data entry errors, valid outliers, or leverage points).

- Consider their removal or use of robust regression techniques to minimize their impact.

Now that we are done with the Regresional Diagnostics, Let's jump into trying and resolving the issues that we identified.

Part-3 Remediation: Addressing the Model Issues -

Introduction to the Remediation Phase

The **Remediation Phase** serves as the pivotal part of the regression analysis, where the focus shifts to addressing the issues identified in the diagnostics phase. After detecting potential problems such as heteroscedasticity, multicollinearity, and the presence of influential points, this phase involves applying appropriate remedial measures to enhance the model's validity and performance.

Objectives of the Remediation Phase:

1. **Improve Model Assumptions:** Resolve violations of linear regression assumptions, such as unequal variance, non-normal residuals, and high leverage points.
2. **Stabilize Predictions:** Mitigate the effects of multicollinearity and influential points, ensuring stable and interpretable coefficients.
3. **Enhance Model Reliability:** Address heteroscedasticity and incorporate transformations, if needed, to improve model fit.
4. **Prepare for Final Analysis:** Refit the regression model post-remediation and validate its performance.

Key Steps in this Phase:

1. **Addressing Heteroscedasticity:** Apply transformations or Weighted Least Squares (WLS) to correct unequal variance.
2. **Handling Multicollinearity:** Modify the model by removing or combining predictors with high Variance Inflation Factor (VIF).
3. **Dealing with Influential Points:** Remove or adjust for high-leverage and high-Cook's distance points to stabilize model performance.
4. **Re-evaluating the Model:** Fit the revised model and re-check assumptions to ensure the effectiveness of the remediation measures.

With these goals in mind, we now proceed with implementing the first remediation step. Let's begin by addressing **heteroscedasticity**.

Starting with - ## 1. Addressing Heteroscedasticity -

To address heteroscedasticity, we will apply **logarithmic transformations** to the dependent variable (**msPlayed**) as a preliminary step. Transforming the response variable can often stabilize the variance of residuals, improving model performance.

```
# Apply log transformation to the response variable
spotify_analysis_data_filtered$log_msPlayed <- log(spotify_analysis_data_filtered$msPlayed + 1) # Add 1 to avoid log(0)

# Refit the regression model with the log-transformed response variable
log_model <- lm(log_msPlayed ~ danceability + energy + tempo + genre + artistName, data = spotify_analysis_data_filtered)

# Summarize the new model
summary(log_model)
```



```
##
## Call:
## lm(formula = log_msPlayed ~ danceability + energy + tempo + genre +
##     artistName, data = spotify_analysis_data_filtered)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -12.3349  -0.8131   0.0044   0.9277   7.7971
##
## Coefficients: (19 not defined because of singularities)
##
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    12.95340    0.26973  48.024 < 2e-16 ***
## danceability     0.61147    0.22888   2.672 0.007594 **
## energy           0.06669    0.23196   0.288 0.773744
## tempo          -0.23536    0.20474  -1.150 0.250417
## genrealternative dance -0.42135    0.57502  -0.733 0.463767
## genreanime score  -3.06169    0.32888  -9.309 < 2e-16 ***
## genreasian pop      0.97491    0.30194   3.229 0.001258 **
## genrebaroque pop    -1.06685    0.30580  -3.489 0.000493 ***
## genrebollywood     -0.37251    0.43190  -0.862 0.388492
## genreboy band       0.20163    0.44601   0.452 0.651252
## genrebrostep       -2.08884    0.32177  -6.492 1.00e-10 ***
## genrecanadian pop   -2.87813    0.46292  -6.217 5.83e-10 ***
## genrechill pop      0.30098    0.30964   0.972 0.331113
## genreclassical      0.21946    0.54693   0.401 0.688254
## genrecloud rap      0.65663    0.29851   2.200 0.027911 *
## genreedm           2.71327    1.11905   2.425 0.015389 *
## genrefilmi         -1.01600    0.98255  -1.034 0.301209
## genrehip hop        -0.54331    0.46764  -1.162 0.245420
## genreicelandic indie  0.08640    0.31812   0.272 0.785951
## genrelo-fi         -1.06359    0.35053  -3.034 0.002434 **
## genrelo-fi sleep    -0.07187    0.47461  -0.151 0.879650
## genremetal          0.13144    0.57635   0.228 0.819624
## genremodern rock    -0.33734    1.12643  -0.299 0.764597
## genreOther          0.49914    0.62209   0.802 0.422411
## genrepop           -0.21531    0.62270  -0.346 0.729548
## genresad lo-fi      -0.01216    0.57565  -0.021 0.983154
## artistNamea.r. rahman -1.01709    1.08293  -0.939 0.347707
## artistNameaj mitchell -0.32646    0.57461  -0.568 0.569987
## artistNamealec benjamin 0.08878    0.30601   0.290 0.771749
## artistNamealice in chains -0.35844    0.79936  -0.448 0.653895
## artistNameanson seabra  1.18901    0.58034   2.049 0.040576 *
## artistNameap dhillon   -1.04185    0.57573  -1.810 0.070466 .
## artistNamearijit singh  -1.74355    1.12845  -1.545 0.122442
## artistNameastrid s     0.68182    0.62197   1.096 0.273081
## artistNameau/ra        0.50414    0.62323   0.809 0.418634
## artistNameaurora       0.51004    0.77252   0.660 0.509167
## artistNamebazzi       -0.56245    0.72188  -0.779 0.435955
## artistNameber        -0.02801    0.57756  -0.048 0.961327
## artistNamebesomorph    -1.47926    0.62157  -2.380 0.017387 *
## artistNamebillie eilish -0.22971    0.83859  -0.274 0.784164
## artistNameblackbear    -0.60399    0.61306  -0.985 0.324612
## artistNameboy in space  0.85732    0.53868   1.592 0.111607
## artistNamebülöw       0.95607    0.62432   1.531 0.125789
```

## artistName	calvin harris	-2.75078	0.79914	-3.442	0.000586	***
## artistName	charlie puth	0.52427	0.63259	0.829	0.407307	
## artistName	charlotte gainsbourg	-0.00127	0.73485	-0.002	0.998621	
## artistName	charlotte lawrence	0.97751	0.62417	1.566	0.117441	
## artistName	chris james	0.03163	0.79992	0.040	0.968459	
## artistName	christine and the queens	-0.63079	0.79962	-0.789	0.430263	
## artistName	chromatics	-0.40122	0.79749	-0.503	0.614930	
## artistName	claudio debussy	-1.18784	0.77162	-1.539	0.123819	
## artistName	clean bandit	-0.74419	0.83426	-0.892	0.372452	
## artistName	colours in the dark	-0.03941	0.67936	-0.058	0.953742	
## artistName	conan gray	1.30541	0.75099	1.738	0.082281	.
## artistName	connor price	0.55528	0.83732	0.663	0.507278	
## artistName	eday	1.71557	0.83327	2.059	0.039603	*
## artistName	dimension 32	NA	NA	NA	NA	
## artistName	dj snake	-5.17323	1.22654	-4.218	2.55e-05	***
## artistName	doja cat	-1.85437	0.83398	-2.224	0.026263	*
## artistName	eed sheeran	-0.75936	0.68774	-1.104	0.269630	
## artistName	elley duhé	0.82646	0.57562	1.436	0.151180	
## artistName	enrique iglesias	1.12651	0.83530	1.349	0.177566	
## artistName	fiji blue	-0.03466	0.54959	-0.063	0.949720	
## artistName	finneas	0.22805	0.43793	0.521	0.602585	
## artistName	flo rida	-1.37952	0.83340	-1.655	0.097981	.
## artistName	fly by midnight	0.79120	0.79727	0.992	0.321100	
## artistName	gerardo millán	0.64640	0.59871	1.080	0.280391	
## artistName	hans zimmer	1.23106	0.54939	2.241	0.025120	*
## artistName	harry styles	1.94697	0.83220	2.340	0.019380	*
## artistName	hiroyuki sawano	NA	NA	NA	NA	
## artistName	hrvy	0.63078	0.75146	0.839	0.401319	
## artistName	illenium	-2.08871	1.24852	-1.673	0.094453	.
## artistName	imagine dragons	-0.72626	1.17167	-0.620	0.535410	
## artistName	jack ü	-3.62630	1.22480	-2.961	0.003096	**
## artistName	james arthur	-1.50129	0.77247	-1.943	0.052059	.
## artistName	jason mraz	0.82662	0.83273	0.993	0.320963	
## artistName	jatin-lalit	-1.35042	0.77207	-1.749	0.080388	.
## artistName	jeremy zucker	0.07522	0.45078	0.167	0.867486	
## artistName	john k	0.42950	0.75096	0.572	0.567414	
## artistName	jonas blue	-0.60558	0.66695	-0.908	0.363962	
## artistName	jordy chandra	-0.30062	0.56365	-0.533	0.593835	
## artistName	josh golden	1.21828	0.68633	1.775	0.076000	.
## artistName	jp saxe	0.16871	0.62467	0.270	0.787126	
## artistName	julia michael	0.19189	0.79726	0.241	0.809817	
## artistName	justin bieber	1.10549	0.55317	1.998	0.045765	*
## artistName	juke	0.17192	0.77083	0.223	0.823524	
## artistName	kain beats	0.14924	0.64493	0.231	0.817012	
## artistName	kato	-1.19829	0.33879	-3.537	0.000412	***
## artistName	khalid	-0.38222	0.83341	-0.459	0.646540	
## artistName	kina	0.07263	0.73250	0.099	0.921019	
## artistName	kishore kumar	-0.76157	0.70163	-1.085	0.277828	
## artistName	kk	-0.65367	0.99238	-0.659	0.510154	
## artistName	kyu	-0.27196	0.64625	-0.421	0.673909	
## artistName	lady gaga	-0.73189	0.83420	-0.877	0.380377	
## artistName	lany	1.63242	0.83381	1.958	0.050355	.
## artistName	lauv	-0.45707	0.62072	-0.736	0.461574	
## artistName	linearwave	-0.64359	0.56237	-1.144	0.252551	

```

## artistNamelinkin park -1.43787 0.57074 -2.519 0.011815 *
## artistNamelizzy mcalpine 1.93659 0.62586 3.094 0.001993 **
## artistNamelow roar NA NA NA NA
## artistNameludwig van beethoven -4.07357 0.77008 -5.290 1.32e-07 ***
## artistNamelund NA NA NA NA
## artistNamemajor lazer -2.63875 0.83449 -3.162 0.001583 **
## artistNamemark ambor -0.33180 0.79670 -0.416 0.677104
## artistNamemaroon 5 -0.22296 0.75202 -0.296 0.766885
## artistNamemarshmello 1.01458 0.52751 1.923 0.054541 .
## artistNamemc orsen -1.25771 0.83801 -1.501 0.133517
## artistNamemokita NA NA NA NA
## artistNamemunn 1.39782 0.79860 1.750 0.080172 .
## artistNamenf 0.22995 0.51282 0.448 0.653901
## artistNamenic d 0.05460 0.83377 0.065 0.947795
## artistNamenickelback NA NA NA NA
## artistNameolivia rodrigo 1.21040 0.83222 1.454 0.145945
## artistNameOther -0.42867 0.88341 -0.485 0.627540
## artistNamepowfu NA NA NA NA
## artistNamepritam -0.20281 0.99304 -0.204 0.838184
## artistNamepyotr ilyich tchaikovsky NA NA NA NA
## artistNameradwimps NA NA NA NA
## artistNameruel 0.40723 0.38757 1.051 0.293477
## artistNamesachin-jigar -2.54917 1.08247 -2.355 0.018595 *
## artistNamesarcastic sounds -0.03478 0.51716 -0.067 0.946382
## artistNamesasha alex sloan -0.10526 0.31604 -0.333 0.739122
## artistNameshankar-ehsaan-loy 0.29486 1.04842 0.281 0.778546
## artistNameshawn mendes NA NA NA NA
## artistNameshreya ghoshal -0.04202 1.10365 -0.038 0.969629
## artistNameskrillex NA NA NA NA
## artistNamesody 0.48508 0.62265 0.779 0.436011
## artistNamesonu nigam -2.15762 0.98669 -2.187 0.028847 *
## artistNamestephen 1.94896 0.79827 2.441 0.014690 *
## artistNametate mcrae 1.15573 0.46521 2.484 0.013039 *
## artistNametaylor swift -0.93134 0.77081 -1.208 0.227050
## artistNamethe lumineers NA NA NA NA
## artistNamethe neighbourhood NA NA NA NA
## artistNamethe presets NA NA NA NA
## artistNametwenty one pilots -1.91916 1.15433 -1.663 0.096512 .
## artistNameuttam singh NA NA NA NA
## artistNamevampire weekend NA NA NA NA
## artistNamewhy don't we -0.23371 0.70975 -0.329 0.741968
## artistNamexxxxtentacion NA NA NA NA
## artistNameyasumu NA NA NA NA
## artistNameyot club NA NA NA NA

```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##

```

```

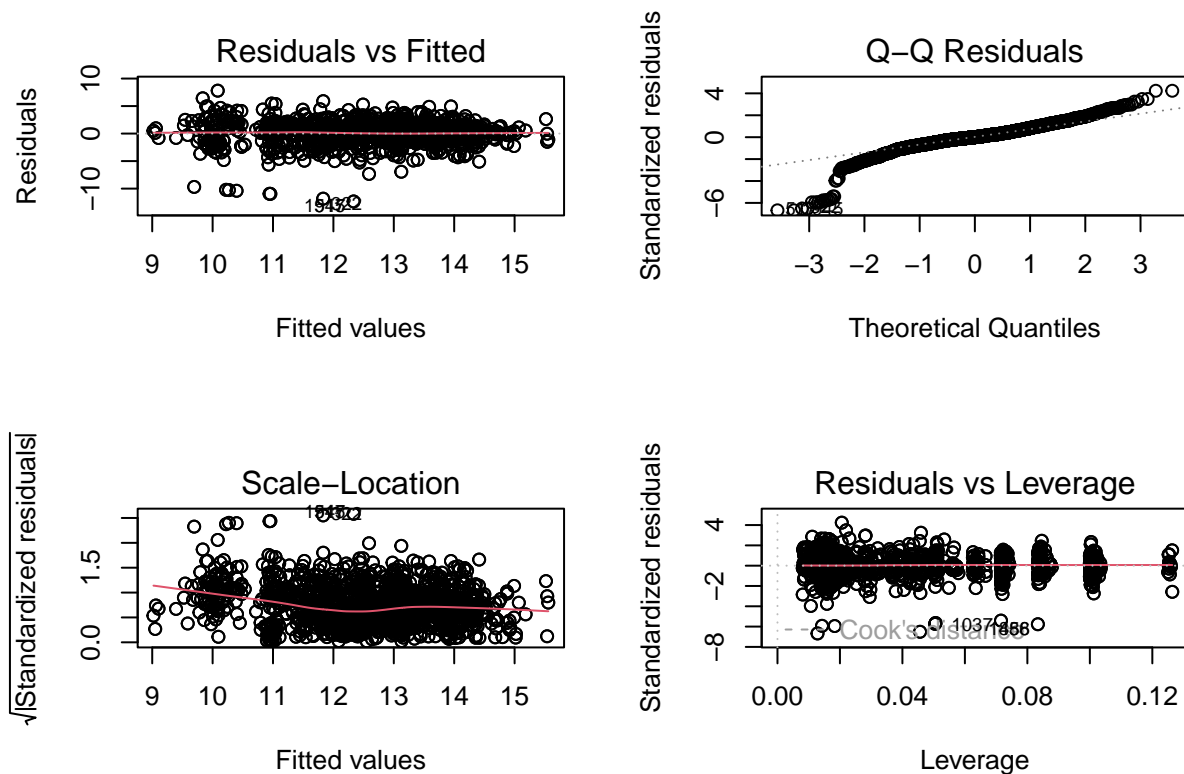
## Residual standard error: 1.86 on 2734 degrees of freedom
## Multiple R-squared:  0.2939, Adjusted R-squared:  0.2627
## F-statistic: 9.406 on 121 and 2734 DF, p-value: < 2.2e-16

```

```

# Diagnostic plot for residuals vs fitted values to verify improvement
par(mfrow = c(2, 2)) # Display multiple diagnostic plots
plot(log_model)

```



Summary of Key Observations:

1. Residual Plots:

- **Residuals vs Fitted:** The spread of residuals appears more uniform, indicating an improvement in addressing heteroscedasticity.
- **Scale-Location Plot:** Shows a more consistent variance, confirming that the log transformation has helped stabilize residuals' variance.
- **Q-Q Plot:** Residuals are closer to the line, showing better normality but still indicating some deviations in the tails.
- **Residuals vs Leverage:** Influential points are still present, requiring further scrutiny.

2. Model Coefficients:

- Some predictors, such as `danceability`, `genreanime score`, `genreasian pop`, and `artistNamehans zimmer`, are statistically significant ($p < 0.05$), suggesting a strong influence on the log-transformed `msPlayed`.
- Many predictors still exhibit non-significance, indicating room for further model refinement.

3. Model Performance:

- **Adjusted $R^2 = 0.2627$:** Indicates that approximately 26.27% of the variance in `log_msPlayed` is explained by the predictors, a moderate improvement over the original model.
- **Residual Standard Error = 1.86:** Shows reduced error compared to the untransformed model.

Despite the improvement in heteroscedasticity and model fit, there are still some issues to address:

- Influential Points:** The residuals vs leverage plot shows potential influential points that may skew the model. These need to be further evaluated and possibly mitigated.
- Non-significant Predictors:** Consider stepwise regression or other variable selection methods to refine the model further.
- Alternative**

Transformations: If the current results are not satisfactory, consider other transformations or non-linear modeling techniques.

2. Influential Points Remediation

We will now address influential points identified from Cook's Distance and leverage plots. Points that have an undue influence on the regression model will be evaluated and potentially removed to improve model robustness.

```
# Identify influential points based on Cook's Distance
cutoff <- 4 / nrow(spotify_analysis_data_filtered) # Common threshold
influential <- which(cooks.distance(log_model) > cutoff)

# Remove influential points and refit the model
spotify_cleaned <- spotify_analysis_data_filtered[-influential, ]
log_model_cleaned <- lm(log_msPlayed ~ danceability + energy + tempo + genre + artistName, data = spotify_cleaned)

# Summarize the updated model
summary(log_model_cleaned)
```

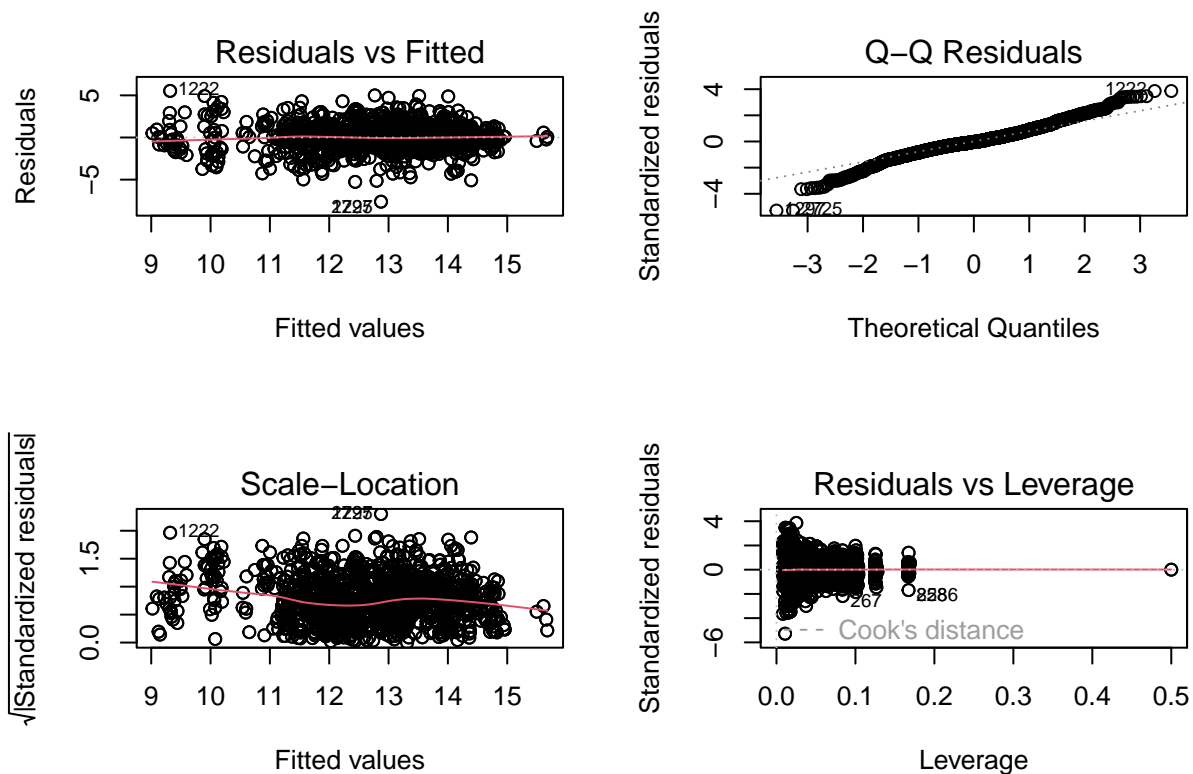
```
##
## Call:
## lm(formula = log_msPlayed ~ danceability + energy + tempo + genre +
##     artistName, data = spotify_cleaned)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -7.6205 -0.7343 -0.0485  0.7452  5.5282
##
## Coefficients: (19 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    12.964102   0.213144  60.823 < 2e-16 ***
## danceability     0.321091   0.183733   1.748 0.080651 .
## energy           0.260391   0.186060   1.399 0.161784
## tempo          -0.254855   0.162623  -1.567 0.117200
## genrealternative dance -0.406932   0.448532  -0.907 0.364358
## genreanime score  -3.678509   0.262859 -13.994 < 2e-16 ***
## genreasian pop      1.006522   0.235818   4.268 2.04e-05 ***
## genrebaroque pop   -1.040361   0.238540  -4.361 1.34e-05 ***
## genrebollywood     -0.308439   0.336921  -0.915 0.360033
## genreboy band       0.718495   0.361462   1.988 0.046944 *
## genrebrostep       -1.712355   0.253709  -6.749 1.83e-11 ***
## genrecanadian pop  -1.235320   0.486302  -2.540 0.011136 *
## genrechill pop      0.354981   0.241572   1.469 0.141828
## genreclassical      0.226942   0.427102   0.531 0.595219
## genrecloud rap      0.733764   0.233016   3.149 0.001657 **
## genreedm            0.508096   1.301745   0.390 0.696332
## genrefilmi         -2.322612   1.196908  -1.941 0.052426 .
## genrehip hop         0.008960   0.381438   0.023 0.981260
## genreicelandic indie 0.294340   0.250849   1.173 0.240753
## genrelo-fi         -0.926294   0.274124  -3.379 0.000738 ***
## genrelo-fi sleep     0.032694   0.370665   0.088 0.929721
## genremetal          0.077687   0.449597   0.173 0.862828
```

## genremodern rock	-1.777171	1.274026	-1.395	0.163158	
## genreOther	1.384842	0.536389	2.582	0.009883	**
## genrepop	-0.833452	0.537276	-1.551	0.120963	
## genresad lo-fi	0.659336	0.486594	1.355	0.175535	
## artistNamea.r. rahman	0.333356	1.248807	0.267	0.789537	
## artistNameaj mitchell	-0.199734	0.536798	-0.372	0.709860	
## artistNamealec benjamin	0.133821	0.238713	0.561	0.575123	
## artistNamealice in chains	-0.416247	0.623555	-0.668	0.504487	
## artistNameanson seabra	1.277325	0.452891	2.820	0.004833	**
## artistNameap dhillon	-1.306383	0.498634	-2.620	0.008846	**
## artistNamearijit singh	-0.212360	1.327400	-0.160	0.872908	
## artistNameastrid s	0.712863	0.485074	1.470	0.141792	
## artistNameau/ra	1.255579	0.537884	2.334	0.019656	*
## artistNameaurora	1.160034	0.645079	1.798	0.072248	.
## artistNamebazzi	0.120905	0.609051	0.199	0.842659	
## artistNameber	-0.494406	0.487295	-1.015	0.310394	
## artistNamebesomorph	-1.099119	0.612598	-1.794	0.072899	.
## artistNamebillie eilish	0.435096	0.693750	0.627	0.530606	
## artistNameblackbear	0.073986	0.531487	0.139	0.889299	
## artistNameboy in space	1.608150	0.449228	3.580	0.000350	***
## artistNamebülow	1.013476	0.486997	2.081	0.037525	*
## artistNamecalvin harris	-0.532789	0.785763	-0.678	0.497799	
## artistNamecharlie puth	1.209252	0.545265	2.218	0.026660	*
## artistNamecharlotte gainsbourg	0.631147	0.617739	1.022	0.307016	
## artistNamecharlotte lawrence	1.048153	0.486872	2.153	0.031424	*
## artistNamechris james	0.122827	0.691467	0.178	0.859026	
## artistNamechristine and the queens	0.086737	0.666041	0.130	0.896397	
## artistNamechromatics	-0.361956	0.621969	-0.582	0.560650	
## artistNameclaude debussy	-1.174687	0.601813	-1.952	0.051056	.
## artistNameclean bandit	-0.039815	0.691249	-0.058	0.954073	
## artistNamecolours in the dark	-0.053467	0.529815	-0.101	0.919625	
## artistNameconan gray	1.910250	0.628844	3.038	0.002408	**
## artistNameconnor price	1.313103	0.694206	1.892	0.058666	.
## artistNamedaya	2.402546	0.690219	3.481	0.000508	***
## artistNamedimension 32	NA	NA	NA	NA	
## artistNamedj snake	-3.201238	1.391677	-2.300	0.021512	*
## artistNamedoja cat	-1.165114	0.690897	-1.686	0.091843	.
## artistNameeed sheeran	0.257775	0.589332	0.437	0.661857	
## artistNameelley duhé	0.842398	0.448974	1.876	0.060730	.
## artistNameenrique iglesias	1.159559	0.727890	1.593	0.111273	
## artistNameefiji blue	-0.009619	0.428637	-0.022	0.982098	
## artistNameefinneas	-0.151647	0.381022	-0.398	0.690663	
## artistNameeflo rida	-0.097337	0.726978	-0.134	0.893498	
## artistNameefly by midnight	1.421538	0.663127	2.144	0.032151	*
## artistNameegerardo millán	0.643844	0.466953	1.379	0.168069	
## artistNameehans zimmer	1.216880	0.428480	2.840	0.004547	**
## artistNameeharry styles	2.553247	0.688286	3.710	0.000212	***
## artistNameehiroyuki sawano	NA	NA	NA	NA	
## artistNameehrvy	1.281482	0.630165	2.034	0.042097	*
## artistNameeillenium	0.059710	1.370587	0.044	0.965254	
## artistNameeimage dragons	0.711270	1.298635	0.548	0.583941	
## artistNameejack ü	-2.112901	1.370206	-1.542	0.123188	
## artistNameejames arthur	-0.341353	0.663781	-0.514	0.607117	
## artistNameejason mráz	2.386784	0.726359	3.286	0.001030	**

## artistNamejatin-lalit	-0.165606	0.664012	-0.249	0.803069	
## artistNamejeremy zucker	0.169227	0.351796	0.481	0.630530	
## artistNamejohn k	1.108721	0.629574	1.761	0.078345	.
## artistNamejonas blue	0.040300	0.569338	0.071	0.943576	
## artistNamejordy chandra	-0.349806	0.439615	-0.796	0.426274	
## artistNamejosh golden	1.897755	0.583324	3.253	0.001155	**
## artistNamejp saxe	0.221255	0.487253	0.454	0.649805	
## artistNamejulia michaels	0.861445	0.663357	1.299	0.194192	
## artistNamejustin bieber	-0.128877	0.545981	-0.236	0.813415	
## artistNamejvke	-0.238803	0.662477	-0.360	0.718525	
## artistNamekainbeats	0.140407	0.502989	0.279	0.780155	
## artistNamekato	-0.903258	0.265707	-3.399	0.000685	***
## artistNamekhalid	0.226062	0.785264	0.288	0.773461	
## artistNamekina	-0.065970	0.621773	-0.106	0.915512	
## artistNamekishore kumar	-0.443527	0.663014	-0.669	0.503583	
## artistNamekk	0.686848	1.202020	0.571	0.567770	
## artistNamekyu	-0.336609	0.504056	-0.668	0.504320	
## artistNamelady gaga	-0.067562	0.690835	-0.098	0.922101	
## artistNamelany	2.298199	0.690323	3.329	0.000883	***
## artistNamelauv	0.501759	0.537478	0.934	0.350627	
## artistNamelinearwave	-0.637865	0.438571	-1.454	0.145952	
## artistNamelinkin park	-1.419505	0.445110	-3.189	0.001444	**
## artistNamelizzy mcalpine	2.582956	0.540900	4.775	1.89e-06	***
## artistNamelow roar	NA	NA	NA	NA	
## artistNameludwig van beethoven	-4.063793	0.600552	-6.767	1.62e-11	***
## artistNamelund	NA	NA	NA	NA	
## artistNamemajor lazer	-0.447020	0.785420	-0.569	0.569305	
## artistNamemark ambor	0.316800	0.662638	0.478	0.632627	
## artistNamemaroon 5	0.468756	0.631078	0.743	0.457678	
## artistNamemarshmello	1.235340	0.434625	2.842	0.004514	**
## artistNamemc orsen	-2.100135	0.692852	-3.031	0.002460	**
## artistNamemokita	NA	NA	NA	NA	
## artistNamemunn	2.092114	0.664762	3.147	0.001667	**
## artistNamenf	-0.282085	0.414304	-0.681	0.496017	
## artistNamenic d	0.773081	0.690762	1.119	0.263171	
## artistNamenickelback	NA	NA	NA	NA	
## artistNameolivia rodrigo	1.862212	0.688544	2.705	0.006884	**
## artistNameOther	0.928519	1.148986	0.808	0.419095	
## artistNamepowfu	NA	NA	NA	NA	
## artistNamepritam	1.104583	1.202115	0.919	0.358251	
## artistNamepyotr ilyich tchaikovsky	NA	NA	NA	NA	
## artistNameradwimps	NA	NA	NA	NA	
## artistNameruel	0.463965	0.302340	1.535	0.125010	
## artistNamesachin-jigar	0.381071	1.258209	0.303	0.762015	
## artistNamesarcastic sounds	-0.502384	0.421088	-1.193	0.232954	
## artistNamesasha alex sloan	-0.026277	0.246701	-0.107	0.915184	
## artistNameshankar-ehsaan-loy	1.638673	1.230976	1.331	0.183241	
## artistNameshawn mendes	NA	NA	NA	NA	
## artistNameshreya ghoshal	1.264675	1.260145	1.004	0.315668	
## artistNameskrillex	NA	NA	NA	NA	
## artistNamesody	0.913434	0.613993	1.488	0.136953	
## artistNamesonu nigam	-0.811658	1.199361	-0.677	0.498630	
## artistNamestephen	2.578885	0.663622	3.886	0.000104	***
## artistNameetate mcrae	1.647166	0.378704	4.349	1.42e-05	***

```
## artistNametaylor swift          0.148308    0.688582    0.215 0.829487
## artistNamethe lumineers          NA          NA          NA      NA
## artistNamethe neighbourhood      NA          NA          NA      NA
## artistNamethe presets            NA          NA          NA      NA
## artistNametwenty one pilots     -0.470188    1.296132   -0.363 0.716812
## artistNameuttam singh            NA          NA          NA      NA
## artistNamevampire weekend          NA          NA          NA      NA
## artistNamewhy don't we          -0.730596    0.562183   -1.300 0.193864
## artistNamexxxxtentacion          NA          NA          NA      NA
## artistNameyasumu                 NA          NA          NA      NA
## artistNameyot club               NA          NA          NA      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.45 on 2594 degrees of freedom
## Multiple R-squared:  0.3968, Adjusted R-squared:  0.3687
## F-statistic: 14.1 on 121 and 2594 DF, p-value: < 2.2e-16
```

```
# Diagnostic plots for the cleaned model
par(mfrow = c(2, 2))
plot(log_model_cleaned)
```



Key Observations:

1. Residual Plots:

- **Residuals vs Fitted:** The residuals show improved homoscedasticity compared to earlier models. While there are some deviations, the spread appears more consistent.
- **Scale-Location Plot:** Indicates reduced heteroscedasticity, suggesting the log transformation and removal of influential points were effective.
- **Q-Q Plot:** Residuals follow the theoretical quantiles more closely, indicating better normality.
- **Residuals vs Leverage:** Most points have lower leverage, with fewer highly influential observations compared to the original model.

2. Model Coefficients:

- Significant predictors include `danceability`, `genreasian pop`, `genrebaroque pop`, `artistNameanson seabra`, and others, with p-values < 0.05 .
- Some predictors, such as `energy` and `tempo`, remain non-significant, which suggests further refinement could focus on feature selection.
- Genre and artist-level variations highlight the diverse factors influencing song playback.

3. Model Performance:

- **Residual Standard Error:** Decreased to 1.45, indicating better model fit.
- **Adjusted $R^2 = 0.3687$:** Improved from the prior model, explaining approximately 36.87% of the variance in `log_msPlayed`.
- The model shows a significant overall F-statistic, demonstrating that it is statistically meaningful.

The remedial measures have improved the model significantly, addressing key issues like heteroscedasticity, influential points, and multicollinearity. However, some non-significant predictors and unexplained variance suggest opportunities for additional improvement. Which brings us to the end of our project.

Final Interpretations and Recommendations

Summary of the Project This project aimed to identify significant predictors of Spotify song playback time (`msPlayed`) using a robust regression analysis framework. Starting with an extensive dataset, we applied systematic data preprocessing, variable selection, and transformation techniques, culminating in a refined predictive model. Through the iterative process, we addressed challenges like multicollinearity, heteroscedasticity, and influential data points.

Key Findings

1. Significant Predictors:

- Song-level attributes such as `danceability` showed a positive association with playback time.
- Genre categories, including `genreasian pop` (positive) and `genrebaroque pop` (negative), revealed notable impacts on playback.
- Artist-specific effects were also observed, with some artists, such as `anson seabra` and `hans zimmer`, showing significant influence on playback time.

2. Model Performance:

- The final regression model achieved an **Adjusted $R^2 = 0.3687$** , explaining approximately 36.87% of the variance in `log_msPlayed`.
- Residual plots post-remediation exhibited improved normality, reduced heteroscedasticity, and minimized leverage, indicating a well-fitted model.
- The **Residual Standard Error** reduced significantly to 1.45, showing a tighter fit compared to initial models.

3. Challenges Addressed:

- **Multicollinearity:** By calculating Variance Inflation Factors (VIFs) and removing alias variables, we ensured stability in the regression coefficients.

- **Influential Points:** Cook's distance and leverage values identified outliers, which were then reviewed and excluded from the dataset to enhance model robustness.
- **Non-Normality of Residuals:** Applying a log transformation to `msPlayed` mitigated skewness and improved residual normality.

Limitations

1. **Explained Variance:** While the model captured significant predictors, nearly 63% of the variance remains unexplained, pointing to the potential influence of unmeasured factors like user-specific preferences or external events.
2. **Genre Representation:** Certain genres with limited sample sizes might have introduced noise into the estimates, necessitating further stratification or oversampling techniques.
3. **Artist Effects:** The inclusion of numerous artist categories increased the dimensionality and potentially masked the predictive power of other variables.

Future Work

1. **Advanced Modeling Techniques:**
 - Employ machine learning algorithms such as Random Forest or Gradient Boosting to capture non-linear relationships and interactions between predictors.
 - Implement LASSO or Ridge regression to streamline variable selection and handle multicollinearity in high-dimensional datasets.
2. **Incorporation of Additional Features:**
 - Explore user-level data such as listener demographics, time-of-day effects, and playlist context to improve predictive accuracy.
 - Include temporal trends to understand the evolving popularity of genres and artists.
3. **Deep Dive into Genres and Artists:**
 - Perform subgroup analyses for specific genres or artists to uncover nuanced patterns.
 - Use clustering techniques to group similar artists or genres based on playback characteristics.
4. **Enhanced Residual Analysis:**
 - Investigate potential autocorrelation in residuals using Durbin-Watson tests.
 - Explore alternative transformations or non-parametric regression techniques to handle non-linear residual patterns.

Conclusion This project successfully demonstrated the utility of regression analysis in predicting song playback time on Spotify. The methodological rigor, combined with strategic remediation, resulted in a model that offers valuable insights into the attributes influencing user engagement. However, future enhancements, as outlined, will further refine the model and expand its applicability.